# DEPARTMENT OF COMMERCE TECHNOLOGY PROGRAMS

## HEARINGS

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

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# DEPARTMENT OF COMMERCE TECHNOLOGY PROGRAMS

TUESDAY, MARCH 7, 1989

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
*Washington, DC.*

The subcommittee met at 9:45 a.m., pursuant to notice, in room 2226, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Campbell, Ritter, Nagel, Henry, Johnston, Boehlert, Skaggs, and Morella.

Mr. WALGREN. Let me call us to order and wish everybody a good morning.

This Committee and the Department of Commerce have a unique opportunity to work together this year to help American business develop the high quality and advanced technology products needed to close the trade deficit.

Throughout the 100th Congress we built toward this point. As our largest contribution to the Omnibus Trade and Competitiveness Act that the Congress passed last year, this Subcommittee made an important effort to create the National Institute of Standards and Technology out of the original National Bureau of Standards and lay the groundwork for far closer extensive cooperation between industry and government in science and technology.

We envisioned a variety of new cooperative programs. This includes the Advanced Technology Program, which will help start American high technology joint ventures to compete with government subsidized overseas competition and also the Technology Extension Service and the Regional Centers for the Transfer of Manufacturing Technology which are designed to help small and medium-sized manufacturers gain access to new technologies that they need to automate and to compete.

As part of the FY-1989 NIST Authorization Act, the Committee supported former Commerce Secretary Verity in his efforts to restructure the technology components of the Department of Commerce into a Technology Administration and, most importantly, a Technology Administration headed by an Under Secretary in rank. The Act also envisioned that the National Technical Information Service would become a modern collector and transmitter of the government's and the world's scientific and technical literature.

Unfortunately, word of these efforts in the Congress failed to plumb the depths of the Office of Management and Budget, and

President Reagan's final budget, which we consider here today, proceeds as if that Omnibus Trade and Competitiveness Act was never really made the law of the land.

We regret that none of those many points of light that have been cited with such pride by the incoming Administration has yet to be revealed in the budgets supported by the Administration for the Department of Commerce.

We also feel that the testimony before us today does not reflect the forward-looking views set out in Secretary Mosbacher's testimony at his confirmation hearing before the Senate Commerce Committee, and we all know that apparently we are still in the middle of a transition.

I hope we can look beyond this particular budget document to talk about the implementation of what were truly bipartisan programs and begin considering the additional changes that must be made in the Department of Commerce as we attempt to meet the challenges put forward by our major trading partners.

With that, I would like to reserve a place in the record for the opening statement of Congressman Boehlert, who I understand is on his way, and recognize our colleague from California, Mr. Campbell, for any comments that he might like to make.

Mr. CAMPBELL. Thank you, Mr. Chairman. I know my colleague from New York will have a few remarks, generally, as I surmise along the same lines as the Chairman.

In welcoming our panel this morning, I would just like to put on the record my concern that in trying to reclaim America's competitiveness in international trade, that we achieve through United States methods and not necessarily emulate the examples of foreign countries where it is contrary to the United States example. By that I mean that the competitiveness of our industry can as readily be assured by consortia and free enterprise as by government grant.

And whereas I share the Chairman's concern about the failure to fund programs authorized by the Congress in this area, I'm also hopeful that the inventiveness and genius of the American competitive system can supply what perhaps the government in its draft budget situation cannot.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Campbell.

Well, let me call our first panel at this point. William Manly, Chairman of the Visiting Committee on Advanced Technology for the National Institute of Standards and Technology makes up the first portion of the hearing today.

We appreciate your being here and look forward to your views as part of our record.

Mr. Manly, as you know, written statements will be incorporated and reproduced in the record in full and you can feel free to underscore and focus or highlight any particular point that you feel you would like to emphasize in the oral presentations.

Before we begin, let me recognize Mr. Ritter for any opening statement he might like to make.

Mr. RITTER. Thank you, Mr. Chairman.

Dealing with the ice and snow this morning was one of those things where all the modern technology in the world couldn't seem to help. [Laughter.]

Mr. Chairman, before I begin my statement, I would like to extend my sincere congratulations to some of the people who will be testifying here today, to Dr. Kammer who will be the new NIST Director, to welcome Dr. Ernie Ambler, who I see out there, whom we have been working with over the years, and to welcome my good friend, William Manly.

Last September I supported a NIST authorization bill saying that it would tell the world that we are committed to winning the race to commercialize new science and technology. The new NIST should help us to compete with global giants, most notably the Japanese who forged ahead in bringing science and technology to the marketplace at an ever accelerating pace.

In the 100th Congress we reorganized the NIST into something more, the National Institutes of Standards and Technology. That wasn't a name change, but today we need even more to rely upon the NIST to strengthen the science and technology base that is critical for our industry, for our jobs, our standard of living and our global competitiveness.

The new Technology Administration of the Department of Commerce could be a pivotal force in leading the U.S. charge to the forefront in science and technology. The new NIST should have a strong sense of purpose at this—a very appropriate time. We need better coordination and collaboration in private sector research and development and cutting edge technologies, and the government can help to facilitate that.

That's part of the secret of Japan's success in so many fields where the Japanese have caught up and taken the lead. We should be transferring even more of the technology developed by the NIST out to the small and mid-sized firms that need it the most. We should be transferring more of the technology and science put forth by the Federal Government and transferring it to American industry.

The Advanced Technology Program could do wonders in facilitating collaborative efforts on the part of industry. Such efforts underpinning America's global competitiveness should not be the exclusive preserve of an agency of national security, the Department of Defense.

We also had a strong commitment for NIST to be a kind of focus for best practices and quality, a quality kind of best practices informational repository, if you will. I would be interested to hear how that's going. That was also in the Trade Bill Amendments.

I say NIST should have a strong sense of purpose for all of this because in spite of all the hopes that have been raised, the fiscal year 1990 Technology Administration budget really doesn't deliver upon the promise of last fall. We really haven't provided resources for a modernized NIST.

On the whole, NIST's budget is down slightly. Even though the Regional Centers for Transfer of Manufacturing Technology would go some way towards ceding the achievement of the goal of bringing advanced technology and manufacturing to mid-sized firms, the agency's budget eliminates funding for them.

One of the key innovations in the Trade Bill for the NIST was what I had mentioned before, the new advanced technology programs. This could be a focal point for generating greater cooperation between players and the private sector with government as the facilitator. Sadly, it received zero funding this year.

Mr. Chairman, that is not as it should be. NIST should regain its preeminent status as one of America's flagship R&D facilities working directly with the private sector in areas where promising breakthroughs are occurring almost daily, such as high temperature superconductivity, biotechnology, photonics optoelectronics and, as we had mentioned, advanced manufacturing.

I hope that our witnesses will address the promise for upgrading our support for NIST.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Ritter.

With that, let's turn to our first witness, and we expect Mr. Boehlert will be along shortly.

Welcome to the Committee, Mr. Manly, and please proceed.

**STATEMENT OF WILLIAM D. MANLY, CHAIRMAN, VISITING COMMITTEE ON ADVANCED TECHNOLOGY FOR THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, ACCOMPANIED BY DALE HALL, EXECUTIVE DIRECTOR, VISITING COMMITTEE ON ADVANCED TECHNOLOGY, NIST**

Mr. MANLY. Thank you, Mr. Chairman and Members of the Committee.

I am pleased to appear before this Committee today as Chairman of the Visiting Committee on Advanced Technology of the National Institute of Standards and Technology.

I am joined at the table by Mr. Dale Hall, the Executive Director of the Committee.

The Committee was established by the Trade Bill of '88 as the principal private sector adviser of the Institute. The Committee reviews and makes recommendations regarding the general policy, organization, budget and programs.

Besides myself, the Committee has eight other members with diverse backgrounds from industry, academia and government. Dr. Arden Bement, Vice President for Technical Resources at TRW and Vice Chairman of the Committee will appear before you tomorrow.

The other members of the Committee are listed in my testimony and I don't see the necessity of repeating them today.

In addition to serving as Chairman of the Visiting Committee, I am speaking with a perspective of a 40-year career that includes service in both government and the manufacturing industry. I began my career at the Oak Ridge National Laboratory and spent 15 years there, then joined Union Carbide and later Cabot Corporation and had several different positions. I retired in 1986 as Executive Vice President from Cabot Corporation and returned to Tennessee and became a consultant to the Oak Ridge National Laboratory where I am assisting in transferring technology from the National Laboratory to American industry.

My remarks today reflect the concerns and opinions of the Visiting Committee. The subjects I will discuss are covered in greater detail in the Visiting Committee Annual Report which was recently submitted to the Secretary of Commerce to be submitted to Congress, and I have a copy with me this morning.

I would first like to speak on the value and quality of the Institute's research.

The first thing I want to emphasize is that the overall caliber of the scientific and technical programs at the Institute is outstanding. The research continues to be of excellent quality and continues to produce science and technology of great value to the nation.

But I would like to point out the Institute research addresses a wide range of national needs. During the past year, for example, they made contributions in industrial process technology, electronic communications, national health, computer security and the investigation of major disasters. Those were some of the areas that were covered.

In recent years the Institute has directed a large fraction of its new resources toward emerging technologies that the Department of Commerce has identified as vital to our future economic competitiveness. These technologies include advanced materials, electronics and optoelectronics, automation, biotechnology, computing medical technology, thin layer technology and superconductivity. The Visiting Committee supports the Institute's work in these areas.

At the same time though, NIST does and must continue to support the critical established technologies on which large sectors of the American manufacturing industries now depend. Much has been said about the transition from a manufacturing economy to a service or post-industrial economy.

However, I share the view that has been expressed by the National Academies of Science and Engineering Report that we are in a transition to a new kind of industrial economy. The manufacturing sector will always be essential to our economic well being. The programs at the Institute maintain a good balance between the emerging technologies critical to our future and the established technologies that will keep our economy strong.

I would now like to speak about NIST's expanded mission in technology competitiveness. The provisions of the Trade and Competitiveness Act that relate to NIST, the passage of this Act in August of last year was one of the most significant events in the Institute's history. The Act gives the Institute an expanded role in helping American industry to remain technologically competitive and encourages the Institute to interpret its charters broadly. At the same time, the Act reinforces the importance of NIST's tradition mission to provide measurements, calibrations and quality assurance techniques that underpin American commerce.

The new technology transfer responsibilities are well placed at the Institute. It already has strong traditions of working with industry and developing science and technology to meet the national needs.

The most visible accomplishment of the new technology transfer programs was the selection of the first three Regional Centers for the Transfer of Manufacturing Technology. We on the Visiting

Committee have great expectations for these Centers in helping small businesses to acquire the technology they need to develop new products and processes and we hope that this continues.

Congress was quite clear about what it wanted the Institute to do when it passed the Trade Act. We are concerned, however, that the expectations of the Congress and American industry will not be met unless the necessary resources are provided.

One of the primary new programs created by the Trade Act, the Advanced Technology Program, is currently unfunded and thus dormant. Mr. Bement, the Vice Chairman of this Committee will speak about this tomorrow in his testimony to your Committee.

The Institute is ready and able to carry out its new technology transfer assignments, but must be given the wherewithal to do the job.

Let me also make an important point here. The Committee is unanimous in its conclusion that the new technology transfer activities, no matter how important, must not be funded at the expense of the existing or future science and engineering programs at the Institute. These science and engineering programs are, after all, the foundation on which successful technology transfer programs must depend. I am certain that this position is widely shared among those in American industry who know the Institute and its work and depend on the output of its programs.

Where will the new resources come from? We believe that both Congress and the Administration must take a larger view of the Institute's budget if the hopes embodied in the Trade Act are to be realized by increasing the Institute's overall funding and providing resources for both technology development and technology transfer.

I would now like to move to the Department of Commerce's Civilian Technology Advocate.

The Department of Commerce should move aggressively to become the principal agency proponent of Federal efforts in civilian technology. At present these efforts in civilian technology are dispersed among many agencies, which include the Department of Defense and the Department of Energy.

The recent establishment of the Under Secretary for Technology in the Department is a strong step in the right direction. We hope that the Under Secretary will fulfill two functions: first, act as a focal point to the various science and technology related activities within the Department and, secondly, be an external spokesman and representative in the arena of national technology policy.

We are pleased with the efforts we have watched so far from the Acting Under Secretary, Dr. Ernie Ambler.

I would now like to turn to the current Institute's budget and resources.

As you know, 1989 is a difficult year for the Institute due to the serious budget shortfall. This budgetary problem is particularly unfortunate in the wake of the Trade Act, which led American industry and the Institute itself to believe that the necessary resources would be provided to carry out its expanded mission.

We recommend that sufficient funds be authorized and appropriated in 1990 to relieve the current difficulties and to fund the 1990 budget initiatives in full.

Looking to the future, the Administration and Congress must work together to make Federal funding of civilian technology a high-priority item on the nation's agenda.

The Visiting Committee believes that providing adequate funding for the Institute to allow real growth in a time of technological challenge and to implement the programs already framed out in the Trade Act is the way we should move forward.

Thank you very much, Mr. Chairman.

[The prepared statement of Mr. Manly, plus the 1988 annual report follows:]

STATEMENT OF MR. WILLIAM D. MANLY
CHAIRMAN, VISITING COMMITTEE ON ADVANCED TECHNOLOGY
OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY;
CONSULTANT, OAK RIDGE NATIONAL LABORATORIES;
AND FORMER EXECUTIVE VICE PRESIDENT OF CABOT CORPORATION
BEFORE THE SUBCOMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES
ON AUTHORIZATION OF APPROPRIATIONS FOR THE ACTIVITIES
OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
MARCH 7, 1989

Mr. Chairman and Members of the Committee:

I am pleased to appear before this Committee today as the Chairman of the Visiting Committee on Advanced Technology of the National Institute of Standards and Technology. The Committee was established by the Omnibus Trade and Competitiveness Act of 1988. As the principal private sector advisor of NIST, the Committee reviews and makes recommendations regarding its general policy, organization, budget, and programs.

Besides myself, the Committee has eight other members with diverse backgrounds: Dr. Arden Bement, Vice President for Technical Resources at TRW, Inc., and Vice Chairman of the Committee, who will testify later in these hearings; Dr. William Howard, a Senior Fellow of the National Academy of Engineering; Dr. Jeanette Grasselli, Distinguished Visiting Professor and Director of Research Enhancement at Ohio University; Dr. William Slichter, retired Executive Director of Research in Materials Science and Engineering at Bell Laboratories; Dr. Nolen Ellison, President of Cuyahoga Community College; Dr. John Bollinger, Dean of Engineering at the University of Wisconsin; Dr. John McTague, Vice President of Research at Ford Motor Company;

and Dr. William Spencer, Vice President of the Corporate Research Group at Xerox Corporation.

In addition to serving as Chairman of the Visiting Committee, I am speaking with the perspective of a forty year career that includes service in both government and the manufacturing industry. I began my career at the Oak Ridge National Laboratory, where I was a metallurgist and technical manager. At the Union Carbide Company and later at Cabot Corporation, I held a number of senior technical and business management positions. In 1986, I retired from Cabot Corporation as Executive Vice President. After my retirement from Cabot Corporation, I became a consultant to the Metals and Ceramics Division of Oak Ridge National Laboratory, where I am assisting in transferring technology to American industry.

My remarks today reflect the concerns and opinions of the Visiting Committee. The subjects I will discuss are covered in greater detail in the Visiting Committee's Annual Report, which was recently delivered to the Secretary of Commerce for submission to Congress.

**The Value and Quality of NIST Research**

The first thing I want to emphasize is that the overall caliber of the scientific and technical programs at NIST is outstanding. The research continues to be of excellent quality and continues to produce science and technology of great value to the Nation. The Visiting Committee's Annual Report discusses many specific contributions that NIST has made in the past year. I will not go into detail here, but I would like to point out that NIST research addresses a wide range of national needs. During the past year, for example, scientists and engineers at NIST have made contributions in industrial process technology, electronic communications, national health, computer security, investigation of major disasters, and many other areas.

In recent years, NIST has directed a large fraction of its new resources toward emerging technologies that the Department of Commerce has identified as being vital for our future economic competitiveness. These technologies include advanced materials, electronics and optoelectronics, automation, biotechnology, computing, medical technology, thin layer technology, and superconductivity. The Visiting Committee supports the Institute's work in these areas, which have the potential to generate large new industries.

At the same time, NIST does and must continue to support the critical established technologies on which large sectors of the American manufacturing industries now depend. Much has been said about the transition from a manufacturing economy to a service or postindustrial economy. However, I share the view expressed in a recent report by the National Academies of Science and Engineering: that we are in a transition to a new kind of industrial economy. The manufacturing sector will always be essential to our economic well-being. The programs at NIST maintain a good balance between the emerging technologies critical to our future and the established technologies that will keep our economy strong as we bring those new technologies to commercialization.

It has been said that one of the things industry needs from our government in order to compete effectively in international trade is a "level playing field" abroad. Here, too, NIST makes an essential contribution by ensuring that the interests of the United States are well represented in the international standards community, so that American manufacturers are not penalized by unfair barriers to trade.

**NIST's Expanded Mission in Technological Competitiveness**

I would now like to speak about those provisions of the Omnibus Trade and Competitiveness Act that relate to NIST. Passage of the Act in August of last year was one of the most significant events in the Institute's history. The Act gives NIST an expanded role in helping American industry to remain technologically competitive, and encourages the Institute to interpret its charter broadly; that is, to be enterprising in finding ways to get the job done. At the same time, the Act reinforces the importance of NIST's traditional mission to provide measurements, calibrations and quality assurance techniques that underpin American commerce.

The new technology transfer responsibilities are well-placed at NIST. The Institute already has strong traditions of working with industry and developing science and technology to meet national needs. In fact, NIST has already responded enthusiastically to its new assignments. The most visible accomplishment of the new technology transfer programs was the selection of the first three Regional Centers for the Transfer of Manufacturing Technology. We on the Visiting Committee have great expectations for these centers in helping small businesses to acquire the technology they need to develop new products and processes, and we intend to follow their progress closely.

Congress was quite clear about what it wanted NIST to do when it passed the Trade Act. We are concerned, however, that the expectations of Congress and American industry will not be met unless the necessary resources are provided. The Advanced Technology Program, one of the primary new programs created by the Trade Act, is currently unfunded, and thus dormant. Dr. Arden Bement, the Vice Chairman of the Visiting Committee, plans to discuss the concept and implementation of the Advanced Technology Program in some detail in his testimony tomorrow. Continued funding for the Regional Centers, too, is in question. NIST is ready and able to carry out its new technology transfer assignments, but must be given the wherewithal to do the job.

Let me make an important point here. The Committee is unanimous in its conclusion that the new technology transfer activities, no matter how important, must not be funded at the expense of the existing or future science and engineering programs at NIST. These science and engineering programs are, after all, the foundation on which successful technology transfer programs must depend. I am certain that this position is widely shared among those in American industry who know NIST and its work, and depend on the outputs of its programs. The standards, data, calibrations, characterization, and generic technology development produced at NIST support existing technologies and spawn new ones that American industry needs. We presume that the President's 1990 budget contains no funding for the new Trade Act responsibilities out of a commitment not to "kill the goose that lays the golden eggs," that is, not to starve NIST's laboratory work to fund a larger technology transfer operation.

Where, then, are the new resources to come from? We believe that both Congress and the Administration must take a larger view of NIST's budget if the hopes embodied in the Trade Act are to be realized. The federal government can and should take a positive step to help our Nation to grow out of its trade and budget deficits by increasing NIST's overall funding, providing resources for both technology development and technology transfer. In the larger scheme of things, the resources we are talking about are small. The entire yearly budget of NIST would not purchase a single advanced defense aircraft, and the increments we are discussing, at least in the short term, are even smaller.

**The Department of Commerce as a Civilian Technology Advocate**

I would now like to expand my discussion to include the role of NIST's parent agency, the Department of Commerce, in civilian science and technology. The Visiting Committee believes

that the Department of Commerce is well-positioned to take a leading role in national science and technology issues. This is especially true now that NIST has been given a greater role in *enhancing America's technological competitiveness.*

The Department of Commerce should move aggressively to become the principal agency proponent of federal efforts in civilian technology. At present, these efforts in civilian technology are dispersed among agencies that include the Department of Defense and the Department of Energy. As Dr. Bement will explain tomorrow, the natural focal point for many of these activities is in the Department of Commerce. As long as the funding for civilian technology is concentrated in other agencies with deeper pockets, however, industry will turn to them for help in addressing critical national needs. Only last week, for example, Zenith Electronics and AT&T asked the Department of Defense to help fund a joint project in high definition television (HDTV).

The recent establishment of the Under Secretary for Technology in the Department is a strong step in the right direction. We hope that the Under Secretary will fulfill two functions: first, as a focal point for the various science- and technology-related activities within the Department, coordinating them and integrating them into the broader mission of the Department; and, second, as an external spokesman and representative in the arena of national technology policy.

**Current NIST Budget and Resources**

My final remarks are directed to the current budget and resources of NIST. As you know, 1989 is a difficult year for the Institute, due to a serious budget shortfall. This budgetary problem is particularly unfortunate in the wake of the Trade Act, which led American industry, and the Institute itself, to believe that the necessary resources would be provided to carry out its expanded

mission. The Committee is seriously concerned about the shortfall, and the effects it is having on NIST programs and morale. This situation clearly cannot be allowed to continue without serious harm to the Institute. NIST, with its unique mission among federally-funded laboratories, is an *essential national* resource that must be preserved.

The Visiting Committee has studied the President's 1990 budget request for NIST. We recommend that sufficient funds be authorized and appropriated in 1990 to relieve the current difficulties and to fund the 1990 budget initiatives in full. Those initiatives, which are now before you for consideration, allow NIST to a) expand its programs in emerging technologies such as optoelectronics, high performance composites, bioprocess engineering, and high-temperature superconductors; b) provide needed generic chemical measurement technology to industry; c) carry out government mandates in computer security; and d) upgrade NIST's computing capabilities to meet current and projected demands.

Looking to the future, the Administration and Congress must work together to make federal funding of civilian technology a high-priority item on the Nation's agenda. The Visiting Committee believes that providing adequate funding for NIST to allow real growth in a time of technological challenge, and to implement the programs already framed out in the Trade Act, is a good way to go forward.

William D. Manly

William D. Manly began his business career as a metallurgist at Oak Ridge National Laboratory, Nuclear Division, Union Carbide Corporation, Oak Ridge, Tennessee. During 15 years at Oak Ridge, he served in a number of capacities, including Director of the Gas-Cooled Reactor Program.

In 1964, Manly was named Director of Materials Research for Union Carbide Corporation in New York City; in 1965, he joined Stellite Division of Union Carbide Corporation as Director of Technology. He returned to Carbide's New York office in 1967 as General Manager of New Products and Refractory metals for the newly formed Materials Systems Division. Later that year, he was appointed General Manager, Gas Turbine Products and Chemical Process Equipment. In 1968, he was named a Vice President of Materials Systems Division and in 1969 returned to Kokomo as General Manager of Stellite. When Stellite was purchased by Cabot Corporation in 1970, Manly remained as Chief Executive Officer. In 1971, he was promoted to Group Vice President for Engineered Products, which included responsibility for a number of Cabot Corporation operations both in the United States and abroad. He was elected a Director of Cabot Corporation in February 1973, was named Senior Vice President in 1977, and was named Executive Vice President in January 1985. He retired from Cabot Corporation in 1986. Mr. Manly is now a Consultant in the Metals and Ceramics Division of Oak Ridge National Laboratory, for Martin Marietta Energy Systems, Inc., assisting in transferring technology to American industry.

Manly received both B.S. and M.S. degrees in Metallurgy from the University of Notre Dame. He was the 1972-73 President of the American Society for Metals. He is a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers; American Nuclear Society; and the National Association of Corrosion Engineers. He has served on several U.S. Atomic Energy Commission technical teams, as Chairman of the AEC's Advisory Committee of Reactor Safety, and as a consultant to the President's Science Advisory Committee. He is a member of the Advisory Panel on Office of Technical Systems requested by the Congress of the United States. Manly has been honored as one of the first fellows of the American Society for Metals and is a Fellow of AIME, a Fellow of ANS, and a recipient of a merit award from the American Nuclear Society. In 1974, he was elected to the National Academy of Engineering and received the Notre Dame College of Engineering Honor Award. In 1981, Mr. Manly was made an Honorary Member of the American Society for Metals. In 1983, he was a recipient of the Nathan W. Dougherty Award by the University of Tennessee. In February 1986, Indiana Governor Robert D. Orr named Manly a "Sagamore of the Wabash" for his many contributions to that state. In 1987, he was awarded the Medal for the Advancement of Research by ASM International. Mr. Manly serves on the Boards of Directors of numerous industrial, academic, government and civic organizations.

# ANNUAL REPORT

# 1988

The Visiting Committee on Advanced Technology

of the

National Institute of Standards and Technology

# The Visiting Committee on Advanced Technology of the National Institute of Standards and Technology

## 1988 REPORT SUMMARY

The Visiting Committee on Advanced Technology of the National Institute of Standards and Technology (NIST) was established by the Omnibus Trade and Competitiveness Act of 1988. The Committee, in its role as principal private sector advisor to NIST, reviews and makes recommendations regarding the general policy, organization, budget, and programs of the Institute.

### NIST 1988 Overview.

The scientific and technical accomplishments of NIST in 1988, discussed in more detail in Section 2.3 of the full Report, contributed substantially to the national welfare. The science that helps protect the health and well-being of our citizens was advanced by NIST studies on radon and asbestos measurement, and on replacements for the chlorofluorocarbon refrigerants that damage the ozone layer. The Institute has played a lead role in developing and implementing computer security techniques in the civilian branches of the federal government, and in breaking down the barriers to electronic communication. In its role as a national resource to investigate natural disasters and industrial accidents, NIST investigated the Ashland Oil spill and other disasters in 1988. NIST was also called on as a neutral third party to examine a copy protection scheme proposed for Digital Audio Tape.

Industry will benefit from development at NIST of an automated manufacturing system that serves as an example of how such systems are designed and brought to practical application. The Institute's expertise in making thin-film superconductor devices provides U.S. industry with voltage reference standards unavailable elsewhere in the world. Industry continues to rely heavily on NIST for standard reference materials, data, and calibrations that are used widely in industrial research, quality control, and contract specifications.

NIST has developed programs in emerging technologies that the Department of Commerce has identified as vital to the U.S. economy. These technologies include advanced materials, electronics (including optoelectronics), automation and manufacturing technology, biotechnology, computing, medical technology, superconductivity, and thin layer technology. The Cold Neutron Research Facility under development at NIST is a unique national scientific resource; its design and construction have been managed superbly.

NIST has done a commendable job of initiating its new technology transfer responsibilities resulting from the Trade Act of 1988, and is poised to increase its efforts when additional

funding is received. The most visible achievement of the new programs was the selection of the first three Regional Centers for the Transfer of Manufacturing Technology through a merit competition. These centers should help small- and medium-sized businesses take advantage of recent advances in manufacturing technology from NIST and other federal institutions.

The Institute's work in implementing the Malcolm Baldrige National Quality Award Program during its first year has been outstanding. The Award, created to promote and recognize quality in U.S. industry, has received widespread publicity and has been enthusiastically supported by leading U.S. corporations.

**Policy Issues.**

The Department of Commerce is well-positioned to take a leading role in national science and technology issues, and should move aggressively to become the principal proponent of federal efforts in civilian technology. The creation of an Under Secretary for Technology in the Department is a strong step toward coordinating the science and technology activities within the Department and increasing their external visibility.

The impact of NIST programs on the United States economy, particularly on the manufacturing industries, is critically dependent on strong interactions between NIST and the private sector. The Institute has participated in joint programs with industry for many years, and should continue its efforts to reach industries that could benefit from its expertise, facilities, and technology.

Under the Advanced Technology Program, NIST is allowed to provide start-up funding for joint industrial research and development ventures. The Committee suggests that the funding and contractual aspects of the program might better be assigned directly to the Under Secretary for Technology, rather than to NIST. This arrangement would relieve NIST of the burden of non-technical work, and would elevate the stature of the Advanced Technology Program. Technical management of the program would still be carried out by NIST under this plan.

The organization plan prepared by NIST in response to the Trade Act and submitted to the Department of Commerce in December 1988 will serve NIST adequately until a new Director is appointed. The full Report contains some suggestions for changes to be considered at that time.

**NIST Budget and Resources.**

The Administration and Congress must work together to make federal funding of civilian technology development a high priority. The Committee encourages the federal government to provide the resources NIST needs for real growth and for fulfilling its mandate under the Trade Act, to provide leadership in developing technology that meets national needs. These resources are not now available. In fact, a shortfall in the 1989

NIST budget threatens the health of an agency that has just been given a lead role in promoting U.S. technological competitiveness. This will be interpreted as a lack of commitment by the federal government to continued U.S. leadership in science, technology, and international economic competition.

To correct this situation, sufficient funds should be appropriated in 1990 to relieve the financial pressure on current programs and to fund fully the 1990 initiatives in emerging technologies and other areas. If Congress chooses to fund technology transfer activities that are not included in the President's budget, as was the case in Fiscal Year 1989, this funding should be in addition to, but not in place of, the scientific and engineering activities at NIST in the President's budget. A commitment to the core science and engineering activities at NIST must be maintained.

The Committee also has two other budget-related concerns. First, NIST's ability to carry out its mission under directly-appropriated funds has eroded in the last decade. As a result, NIST in recent years has had to derive an increased fraction of its support from other agencies. This need for indirect funding leaves NIST vulnerable to factors beyond its control, and can have an adverse impact on NIST's ability to carry out its core mission as stated in the Trade Act. While some level of contract support from other agencies is desirable, the Committee is concerned that more directly-appropriated support is required to put the current funding in proper balance.

Second, the new technology transfer activities at NIST involve substantial appropriations for grants. Clearly, the best way to award such grants is through competition based on merit reviews by technical experts. The Committee believes that "directed appropriations," earmarked by legislation for specific uses and recipients, do not fulfill legislative intent, deny the Institute the authority to manage and carry out programs that meet its standards, and are thus an inappropriate way to allocate research funds.

# The Visiting Committee on Advanced Technology of the National Institute of Standards and Technology

## 1988 REPORT

### 1. Introduction.

1.1. Committee Charter.

The Visiting Committee on Advanced Technology of the National Institute of Standards and Technology (NIST) was established by the Omnibus Trade and Competitiveness Act of 1988, referred to below as the Trade Act. The Trade Act empowers the Committee to review and make recommendations regarding the general policy, organization, budget, and programs of the Institute.

The Committee intends to play an active role in providing private sector advice and guidance to NIST. We regard our charter as both a challenge and an opportunity to make a significant contribution to one of the Nation's most respected scientific and engineering laboratories.

The Trade Act specifies that the Annual Report of the Visiting Committee is to address policy issues or other matters that affect the Institute or are of concern to the Committee in its role as the private sector policy advisor of NIST. Further, the report is to identify areas of research in which the Institute possesses special competence that are potentially important to the long-term competitiveness of U.S. industry.

This first Annual Report of the NIST Visiting Committee on Advanced Technology necessarily addresses a broad range of issues and subjects. Subsequent reports will review some of these subjects in more detail after further study and will introduce new issues of a specific nature.

1.2. Committee Operation and Budget.

NIST management has supplied resources and information to assist the Committee in carrying out its work. In accordance with the provisions of the Trade Act, we have requested and been assigned a staff member to provide the Committee with policy, budget, and scientific information and to handle administrative functions. The Committee's future activities will require greater resources than in previous years, including funds for staff, increased travel and other commitments mandated by the Act. The Committee believes, however, that these additional funds should not be provided at the expense of NIST scientific and technical programs.

## 2. NIST 1988 Overview.

### 2.1. Mission and its Fulfillment.

The National Institute of Standards and Technology, maintaining the responsibilities it had when it was named the National Bureau of Standards, serves as the Nation's central reference laboratory for physical, chemical, and engineering measurements. The Institute has a unique mission among federally funded research laboratories, providing measurement science and technology to nearly every economic sector and for nearly every national concern. As the only major federally funded laboratory with a direct mission to support U.S. industry, NIST fills a critical need in helping industry to develop technology for the production of high quality, low cost, internationally competitive goods and services.

We commend the National Institute of Standards and Technology for its enthusiastic response to its new assignments under the Trade Act, while continuing the excellent work in its traditional programs. Increased efforts are needed to ensure that NIST is capable of reaching all of its potential customers and clientele in industry; the provisions of the Trade Act provide a good framework under which these efforts can proceed. The idea of working with industry is embedded in the NIST culture from its days as the National Bureau of Standards, and the Committee expects that NIST, if adequately supported, will carry out its expanded mission with distinction.

### 2.2. Health of Scientific and Engineering Programs.

In a time of transition and assignment of new responsibilities, NIST has maintained a commitment to quality and progress in its science and engineering programs. This was the intent of Congress in the Trade Act, and is essential to preserve this vital national resource on which the success of NIST's new mission depends. The strength of science and engineering research programs at NIST can only be maintained if the new technology transfer programs called for by the Act are funded separately, i.e., not at the expense of existing programs. The Committee strongly recommends against reallocating funds from scientific and engineering research to technology transfer; such reallocation will do irreparable harm to NIST programs and to the U.S. economy.

### 2.3. Accomplishments.

The accomplishments of NIST in 1988 are impressive. The programs at the Institute have continued to provide benefits to industry and to contribute to our national and social welfare. Furthermore, the Institute continues to develop and build scientific and engineering facilities that are valuable national resources, and has developed and implemented programs to support emerging technologies that are vital to the U.S. economy.

Several of these noteworthy accomplishments are summarized in subsections 2.3.1 through 2.3.4.

2.3.1. Benefits to the Nation and Society.

NIST has made substantial contributions to the science base that helps to protect the health of our citizens. In 1988, radon and asbestos exposure were national issues that attracted widespread attention. The potential impact of decisions based on the millions of measurements for radon gas made annually is enormous. NIST has responded by designing a new primary radon measurement system, and is studying serious measurement discrepancies among the principal U.S. laboratories that maintain independent calibration capability. The Institute also established a reference laboratory for analysis of bulk and airborne asbestos, and developed standards and technical requirements for a national laboratory accreditation program so that more accurate measurements are available throughout the U.S. New methods for producing and characterizing reference materials for air filters have been developed, and methods for determining the concentration of asbestos in air for abatement clearance projects have been investigated.

Recent concern about chlorofluorocarbons damaging the ozone layer prompted NIST to produce data needed by industry to develop alternative chemicals for use as refrigerants in refrigerators, freezers, air conditioners, heat pumps, and cooling equipment in commercial buildings. About 70 percent of chlorofluorocarbon emissions are estimated to come from those sources. A theoretical model has been developed to predict the properties of promising alternative refrigerants. NIST has also demonstrated that optimum mixtures of two refrigerants can achieve a 30 percent increase in heat pump efficiency with little or no additional cost in equipment design and manufacture. Strong interactions involving NIST and industrial trade associations, manufacturers, and users are developing in joint efforts to mitigate a worldwide problem.

The importance of computer security has been underscored by the recent reports of computer viruses infecting personal computers and computer networks. Congress assigned NIST the responsibility for dissemination of computer security techniques to the civilian branches of the federal government under the Computer Security Act of 1987. NIST has met all the near-term tasks mandated by the Act, including issuing a regulation on training of managers, computer system operators and users in computer security; providing guidelines for identifying sensitive computer information systems and implementing an agency security plan review; and establishing a Computer Security and Privacy Advisory Board.

Two new Federal Information Processing Standards issued by NIST in 1988 are the crucial first steps in providing a means for disparate computer hardware and software to work together, diminishing the barriers to electronic communication of information. POSIX (Portable Operating System Interface for Computer Environments) is designed to permit transport of computer software between disparate computer hardware. GOSIP (Government Open System Interface Profile) is a technical specification patterned after the Open System Interconnection (OSI), an international standard for data communications. NIST encourages vendors to offer off-the-shelf products that provide a uniform protocol for data communications.

The Institute has frequently been called on as a national resource to investigate natural disasters, industrial accidents, and similar situations. In 1988, the Institute conducted an investigation of the Ashland Petroleum Company oil tank collapse in which nearly one million gallons of oil were spilled into the Monongahela River near Pittsburgh on January 2, 1988. NIST investigators identified the factors that contributed to the tank rupture, and NIST subsequently recommended a review of standards to identify those that could protect against this type of catastrophic failure. The results of the investigation are influencing the development of strategies by the American Petroleum Institute and the Environmental Protection Agency to prevent future failures.

The Institute also assisted in the investigation of the fire in the 62-story First Interstate Bank building in Los Angeles. The investigation team used fire modeling techniques recently developed by NIST to make estimates of the course and rate of fire growth to aid both local and federal authorities in their investigation. NIST is also making its fire models available to the public. HAZARD I, a user-friendly software package developed at NIST for prediction of fire hazards in buildings, is the first thorough integration of fire science into a practical tool for use by fire safety practitioners to predict the fire environment and its impact on the building occupants. In a recent criminal case, the predictions provided by the fire model used in HAZARD I were ruled to be acceptable in court.

After the recent Armenian earthquake, a NIST engineer traveled to Armenia to examine the performance of various types of building systems. This investigation provided valuable information on how various construction techniques and materials performed during a major earthquake and revealed opportunities for cooperative studies with the Soviets to determine the safe use of precast structures in areas of high seismic risk.

The August 4, 1988 flight readiness test firing of the Space Shuttle was aborted because of an indication that a valve was in the wrong position. Subsequent measurements at NIST showed that a material in the valve-position transducer, previously considered nonmagnetic, becomes magnetic at low temperatures under certain conditions. This unexpected behavior can interfere with the operation of the transducer, leading to false readings. An alternate material has been proposed as a solution.

Because of its expertise in measurement science and its reputation for third party neutrality, NIST is often asked to resolve the technical aspects of potentially litigious commercial and patent issues. In 1988, at the request of Congress, NIST examined the proposed copy protection system for digital audio tape (DAT) recorders. Laboratory studies and listening tests designed and conducted at NIST showed that the performance of the system was unreliable, the quality of the prerecorded material was discernibly altered in some cases, and several inexpensive means could be used to bypass the copy-code scheme. As a result of the NIST study, the proposed scheme was abandoned by the recording industry.

### 2.3.2 Benefits to Industry.

In collaboration with industry, NIST developed a state-of-the-art automated manufacturing system for the Navy's Mare Island, Naval Shipyard. The technology of the NIST Automated Manufacturing Research Facility Turning Center has been incorporated into

high performance equipment of Westinghouse/Unimation and Warner and Swasey. The work station produces on demand any of 84 different parts used in nuclear submarines, thus eliminating the need for parts stockpiles. The work station can produce in 30 minutes a part that requires about 17 hours to manufacture using manual production methods. In addition to its utility in making parts, the automated manufacturing system has great value as a paradigm for the development of other automated manufacturing systems by U.S. industry.

With help from NIST, industry has begun to exploit the benefits of low temperature superconductors. The Institute's expertise in fabricating Josephson junction thin-film devices has been used by Hewlett-Packard Corporation, a major U.S. manufacturer of electronic equipment, to establish the performance of a new class of precision multimeters. The 10-volt Josephson junction arrays, which have an accuracy on the order of 10 parts per billion, provide U.S. industry with reference standards unavailable elsewhere for fundamental dc voltage measurements, as NIST has the world's only facility for fabricating the devices.

NIST has been instrumental in establishing a major forum for users and vendors of the emerging Integrated Services Data Network (ISDN) International Standard. ISDN promises to change how telephones are used and to speed up the movement of information around the world. Using ISDN, voice, data, and image signals can be received and sent simultaneously over digital telephone networks using the same equipment. NIST has supported industry and government efforts by providing technical specifications and tests needed to achieve interoperability of ISDN telecommunications services.

To speed the development and use of computer-integrated design, manufacturing and logistic processes, NIST has begun to develop a facility for testing implementations of the Product Data Definition Exchange Specification (PDES). A diverse group of industries, government agencies and universities is developing PDES as a standardized format for representing and exchanging information about almost any manufactured product. The "National Testbed Facility" at NIST will provide a demonstration site for applications of PDES technology and will conduct an information and technology transfer program.

A model developed at NIST will help the steel industry to achieve higher process efficiencies by optimizing slag compositions, coal/iron ore/slag mixtures, and operating temperatures in existing and new steelmaking processes. The model and accompanying database permit detailed composition calculations of multicomponent-multiphase oxide systems representative of typical steel slags and refractories used in steel processing. Several industries are beginning to substitute the NIST model for the overly simplistic chemical models currently used.

A new test technique developed at NIST reduces specimen machining costs by a factor of five compared to methods currently in use to obtain creep and creep rupture data for structural ceramics at temperatures as high as 1500° C. High testing costs have limited the data available to design engineers. The use of laser imaging to measure displacements to accuracies of 1 nm has allowed evaluation of composites with potential applications in heat engines and heat exchangers.

NIST continues to provide standards and calibration services to the scientific and industrial communities. More than 44,000 Standard Reference Materials were sold, producing about $6.5 million in income. The great majority of these standards are sold to industry, and are widely used in research, quality control, and contract specification. Over 13,000 calibration tests were performed on a variety of instruments. Many of the instruments calibrated for industry are used by companies as internal references, against which their other instruments are checked. About $6.3M in income was received from the calibration programs.

2.3.3. Emerging Technologies.

In 1988, NIST had noteworthy accomplishments in several critical emerging technologies, including advanced microelectronics, high temperature superconductors, polymer science, and biotechnology.

Gallium arsenide (GaAs) is perhaps the ultra-high speed semiconductor material of the future. NIST has made progress in GaAs technology on two fronts. In a recent study using the highly sensitive, ultra-high resolution Scanning Tunneling Microscope developed at NIST, atomic-scale "wires" of cesium were observed to grow on GaAs surfaces in regular rows from single-atom chains. Since 20,000 rows would occupy no more space than the width of a single human hair, the electrical conductivity of these "wires" is under intensive study. This work could have enormous impact on both the information storage and lightweight magnetic materials industries. Other NIST studies on gallium arsenide crystals have looked at the defects that can degrade their electronic and optical properties. The NIST synchrotron radiation capabilities for imaging the interior of crystalline materials have been used to observe, for the first time, defects which may explain the performance limits of gallium arsenide semiconductors.

In the high temperature superconductor area, joint work between NIST and Westinghouse has resulted in methods for making electrical contacts with very low electrical resistance to high temperature superconductors. Such low resistance contacts are essential for practical use of superconductors as electrical conductors and for measurement of their electrical properties. Three joint patent applications are being sought on the technology, which has produced contact resistances over one hundred million times lower than available by previous methods. Researchers at several major U.S. corporations are using the new technique in their work. NIST has also developed phase diagrams for two high temperature superconductor systems. Such phase diagrams can be considered as "blueprints" to guide the processing of the materials. In coordination with processing studies, the diagrams have suggested that impurities in the superconducting materials limit their superconducting properties.

Nonlinear optical materials have potential applications in high speed telecommunications, optical computing, and high density information storage. Polymers show promise as improved nonlinear optical materials because of their electronic structures and the ease with which they can be fabricated and processed at moderate temperatures. Work at NIST, for example, has shown how one class of chemicals can be polymerized in the liquid

crystalline state to yield solids with higher optical quality. Another study, carried out in collaboration with IBM, used neutron probes to determine the structure of polymer films. The structure of these films, which are used in the electronics industry, is important because it influences their adhesion.

In the field of biotechnology, NIST recently developed a reproducible, high-resolution technique for the separation of proteins for human tissue analysis. There are tens of thousands of different proteins in human serum. Present research is focused on identifying the individual proteins and characterizing their functions relative to human health. Preliminary joint work between NIST and the National Cancer Institute has shown the absence or presence of specific proteins in different types of carcinomas. It is thus possible that the identification of the unique proteins involved could lead to early warnings or even cures for cancer. The same technology may be useful as a tool for screening candidate chemoprevention agents, and will be used to look at the purity of a host of other biotechnologically produced products.

2.3.4. Scientific and Engineering Facilities as National Resources.

The Cold Neutron Research Facility at NIST was dedicated on January 12, 1989. The facility will provide the U.S. scientific and industrial communities with a new research capability that ranks with the best in the world. Cold neutrons, produced by specially-designed nuclear reactors, are rapidly becoming one of the most important fundamental research tools in materials science, physics, chemistry, and biology. Scientists and engineers from private industry will be able to use the facility for proprietary research, beginning with the startup of three or four of the facility's instruments in 6 to 8 months. Management and execution of the design and construction of the facility have been superb.

2.4. Malcolm Baldrige National Quality Award.

In August, 1987, the President signed P.L. 100-107, The Malcolm Baldrige National Quality Improvement Act of 1987. The Award was created to promote quality awareness, recognize the quality achievements of U.S. companies, and publicize successful quality improvement strategies. NIST has done an outstanding job in implementing the Malcolm Baldrige National Quality Award Program during its first year and in laying the groundwork for future years.

To support the Award, a Foundation was created. Foundation trustees include the Chief Executives of leading U.S. companies, including IBM, General Motors, Ford, Xerox Corporation, TRW, Eastman Kodak, and American Express. More than $9.6 million was raised from more than 100 donor companies to endow the Award. This high level of support from industry is gratifying and necessary for the Award to reach its intended stature.

On November 14, 1988, President Reagan presented the first three awards to Motorola, Inc., the Commercial Nuclear Fuel Division of Westinghouse Electric Corporation, and Globe Metallurgical, Inc. The awards were widely reported in the popular and trade press.

Sixty-six award applications were received from leading quality companies and more than one hundred leading quality experts participated in the selection process.

The Award Program has, as hoped, already begun to have a broader impact on Quality Awareness in business and government. Organizations throughout the United States are adopting the award criteria as quality standards and are using the award materials for self-assessment and training. Other awards, including state, local, Federal, and industry awards, are being patterned after the Baldrige Award. The Award Program has provided information and assistance to state, local, and Federal groups in addition to thousands of businesses. The Quality Office at NIST has promoted the Award through briefings, public talks, and published articles.

The Malcolm Baldrige National Quality Award Program has made a promising start, and the Committee will continue to follow its progress closely.

2.5. Research Programs in Emerging Technologies.

The Department of Commerce reviewed emerging technologies in early 1986 to a) identify those that will lead to new products or processes, b) rank them by economic impact, and c) identify barriers to commercial implementation. The Department's report aggregated the new technologies into seven categories: advanced materials, electronics (including optoelectronics), automation, biotechnology, computing, medical technology, and thin layer technology. The Committee concurs with the importance of these technologies, with the understanding that the category of automation includes manufacturing technology in a broader sense. We also add high temperature superconductivity to the list of new technologies in which we believe NIST should have strong programs.

NIST management has directed a significant fraction of the Institute's new resources to those emerging technologies identified by the Department in which it is vital for the United States to have a leadership position. Many of the research programs in emerging technologies at NIST were started before the Trade Act stressed the importance of NIST's role in these areas. At this time, NIST has before Congress a 1990 budget that requests funding for several initiatives in emerging technologies. These are discussed in more detail in section 4.

We will follow NIST progress in emerging technologies closely and will report our findings in more detail in subsequent reports.

2.6. Other Appropriate Research Areas.

In addition to doing research in emerging technologies, NIST has long carried out programs of benefit to the national welfare. The programs in building technology and fire research are good examples. The Committee believes that the Institute should continue to look for research opportunities in important environmentally-related issues and public safety. Current NIST programs on ozone-safe refrigerants, fire hazards, and radon and asbestos measurements illustrate the kinds of research that should not be overlooked as NIST focuses on enhancing U.S. industrial competitiveness.

The impending commercialization of High Definition Television (HDTV) represents an opportunity that United States industry cannot afford to miss. In addition to the large markets anticipated, successful companies will enjoy increased commercial and technical leverage for exploiting other related technologies in communications and electronics. As recent discussions have made clear, many of the issues involved in implementing HDTV in the U.S. involve standards and regulations. The Committee believes that NIST can play a strong part in assisting U.S. companies to establish and maintain a foothold in HDTV technology.

2.7. Issues for Future Consideration.

The Committee has a keen interest in the impact of NIST on the United States economy, particularly on the manufacturing sector. The Committee intends to examine the economic impacts of selected NIST programs on a continuing basis, and will encourage NIST to generate financial and other data to substantiate its contribution to the national economic welfare.

Strong interactions between NIST and the private sector are critically important in carrying out the responsibilities NIST was given under the Trade Act. The Committee will examine these interactions in 1989, with particular emphasis on NIST participation in joint programs with industry.

The Institute has done an exemplary job of reaching many scientific and industrial organizations, especially those that deal extensively with measurement problems or recognize a need for standard reference data and materials. However, NIST is still not recognized as a valuable resource by many companies that could benefit greatly from its facilities, expertise, and technology. The Committee will work with NIST to help the Institute continue to improve its outreach efforts.

Government laboratories such as NIST that transfer technology to the private sector must consider the legitimate extent of their efforts along the path from fundamental research to final product development, an issue on which there are diverse opinions. Furthermore, the complex multinational nature of many corporations today calls for a policy on how a U.S. company is defined, for the purpose of determining which companies NIST is charged to help. The Committee will explore these and other related matters with NIST.

In the next five years, a considerable turnover of NIST senior personnel is possible due to retirement. This situation represents a management challenge to maintain continuity of leadership but also presents an opportunity to meet the changing needs of the Institute. The competition with universities and industry for top people will be intense, especially since academic institutions and industrial research organizations can and often will make financial offers not possible within the existing federal pay structure. It is not yet clear how the Institute's staffing needs will be affected by either the Personnel Demonstration Project at NIST or by possible changes in the federal pay structure which could influence senior level personnel to defer retirement. The Committee will comment more on personnel-related issues in future reports.

A research organization such as the Institute needs to be well-equipped to stay abreast of advances in science and technology. This is particularly true at a time when the Institute must invest in facilities and equipment to increase its role in technology transfer. However, the cost of research equipment has increased significantly faster than the general inflation rate, as instrumentation has become increasingly sophisticated and powerful. At NIST, for example, the annual cost of depreciable equipment has increased by over 35 percent in the last eight years. The Committee believes that adequate funding for research equipment is necessary to maintain NIST's ability to do state-of-the-art research. In future reports, we will examine the condition and capabilities of major NIST equipment, and plans to buy new equipment or upgrade existing equipment.



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## 3. Provisions of the Omnibus Trade and Competitiveness Act of 1988.

3.1. The Role of the Department of Commerce and NIST in U.S. Industrial Competitiveness.

It is clear that the federal government must increase its research and development expenditures on civilian science and technology in the future. The Department of Commerce is well-positioned to take a leading role in national science and technology issues, and should move aggressively to become the principal proponent of federal efforts in civilian technology. The creation of the Under Secretary for Technology in the Department is a strong step in the right direction. The Under Secretary should serve as a focal point for coordinating the science and technology activities within the Department, and integrating them with the Department's broader mission. The Under Secretary will also increase the external visibility of Commerce in the area of science policy, where Commerce has had little involvement in the past. The Committee will follow the development of the Under Secretary's Office with interest, and requested a briefing from that Office at its February 1989 meeting.

Through the National Institute of Standards and Technology, the Department of Commerce also has a lead role in developing and implementing technology to improve U.S. industrial competitiveness. Passage of the Omnibus Trade and Competitiveness Act of 1988, which created the Institute from the National Bureau of Standards (NBS), was one of the most significant events in the history of the agency. Its provisions call for the Institute to expand its efforts to enhance the competitiveness of American industry, while maintaining its traditional function as the lead national laboratory for providing the measurements, calibrations, and quality assurance techniques that underpin United States commerce and technological progress.

The Committee strongly endorses the expanded mission of NIST and the objectives of the Trade Act. NIST is an excellent choice to carry out the new outreach assignments, given its longstanding experience in working with industry to provide measurement standards, reference data, calibrations, and other research products and services.

We are concerned, however, that the reality of accomplishments will not live up to the expectations of Congress or the Nation without adequate funding. We note, for example, that while $40 million was authorized for the Regional Centers for the Transfer of Manufacturing Technology in the two-year period of Fiscal Years 1989 and 1990, only $7.5 million was appropriated for FY 1989. Even more serious is the lack of any funding in the proposed 1990 budget for the continuation of the centers. Withdrawal of support before the centers have had a chance to establish themselves will condemn the program to failure. Similarly, the Advanced Technology Program, which has been widely referred to as a "civilian DARPA," will certainly not grow to that stature without a large commitment of resources. Other new assignments for NIST under the Trade Act will likewise not reach their full potential unless adequately funded.

3.2. NIST Organization Plan.

3.2.1. Background.

The Trade Act required the National Institute of Standards and Technology to submit an initial organization plan to the Committee on Science, Space, and Technology of the House of Representatives, and the Committee on Commerce, Science, and Transportation of the Senate after consultation with the NIST Visiting Committee on Advanced Technology.

The call for a new organization plan comes at a time of major transition for NIST, driven by four significant events. First, the passage of the Act expanded the agency's role in technology transfer and encouraged NIST to take a broad view of its role in science and technology. Second, the election of a new Administration will produce a new federal science and technology policy. Third, the recent establishment of the Under Secretary for Technology in the Department of Commerce provides a spokesman and leader for the technology-related activities in Commerce, of which NIST is by far the largest. Fourth, the announced retirement of NIST Director Dr. Ernest Ambler in 1989 represents the first change in this post since 1975.

3.2.2. Comments on the Organization Plan.

The Visiting Committee has reviewed the version of the organization plan submitted by NIST to the Department of Commerce on December 9, 1988. The plan adequately addresses the current needs of NIST and will serve NIST until after the appointment of a new Director, which is the appropriate time for any major organizational changes to be implemented. The plan submitted to the Department incorporates some suggestions made by the Committee to NIST management after an earlier plan was discussed.

The proposed organizational changes are primarily directed toward a) rational grouping of technical activities to combine and consolidate competences, and b) meeting the new legislative assignments of the Trade Act. The organization plan maintains the four existing technical Major Operating Units (MOUs) and minimizes disruption to existing research and other programs carried over from NBS. In the Committee's opinion, this latter point is essential, because the outputs from these programs are unique and provide support to the U.S. economy.

The organization plan consolidates some programmatically-related areas below the MOU level, compared to the organization of the last several years. This consolidation should increase communication among researchers in related disciplines. Some exceptions remain. Computer work, for example, continues to be carried out in two organizations within NIST. The missions of these two organizations, however, are distinct and serve different clients. The National Computer Systems Laboratory works primarily for external clients in developing computer standards, architecture and security techniques, while the Center for Computing and Applied Mathematics in the National Engineering Laboratory operates the NIST mainframe computer and provides mathematical and computing services in-house.

A weakness of the plan is that the technical MOUs remain disproportionate in size. Some of the Centers, i.e., units below the MOU level, are larger than some MOUs (e.g., the Center for Electronics and Electrical Engineering, CEEE, is larger than the National Computer Systems Laboratory, NCSL). As a result, some parts of the Institute have proportionately greater representation than others on the NIST Executive Board, at Congressional hearings, in public discussions of their programs, and in Institute-wide activities. In practice, this arrangement does not appear to have caused serious problems, but this issue should be considered in the event of further reorganization. In addition, some MOUs contain centers that work in unrelated disciplines.

The proposal for an organizational unit for Industrial Technology Services provides a framework for meeting the outreach mandates of the Trade Act. Full implementation of the provisions of the Act, as discussed elsewhere in this report, will depend on receiving the required funding. The existing offices for Standard Reference Materials (SRM), Standard Reference Data (SRD), and calibration services, which are well-known NIST outreach services, are to be transferred from the National Measurement Laboratory to Industrial Technology Services. This consolidation of outreach programs under a single management unit should contribute to NIST efforts to reach the broadest possible constituency for its technology and services. However, this separation of the offices from the laboratories also presents a management challenge. Direct contacts between NIST researchers and those outside the organization who use their research outputs, standards, and services must not be impaired, and the marketing and research functions of NIST outreach programs must not be allowed to drift apart.

3.3. Implementation of New NIST Assignments.

NIST has done an excellent job of setting forth an organizational structure and a series of programs to carry out its new technology transfer responsibilities resulting from the Trade Act. A detailed implementation plan has been developed for these new assignments, and NIST is poised to increase its efforts when additional funding is received.

The most visible achievement of the new programs was the selection of the first three regional manufacturing technology centers through a merit competition. The Cleveland Advanced Manufacturing Program in Cleveland, Ohio, Rensselaer Polytechnic Institute in Troy, New York, and the University of South Carolina in Columbia, South Carolina are the organizations chosen to organize the centers in cooperation with NIST. These centers should help small- and medium-sized businesses take advantage of recent advances in manufacturing technology from NIST and other federal institutions. The Institute, having established its competence in the area of manufacturing technology through programs such as the Automated Manufacturing Research Facility, has strong credentials for administering the program.

The regional centers program has already, in the first several months of its existence, attracted considerable attention. NIST reported that several other meritorious proposals were submitted in addition to the three winning programs. As discussed above, the Committee believes that advances in manufacturing technology are essential in enhancing

America's global economic competitiveness, and will follow the progress of the regional centers with interest.

In other new activities, state and local organizations offering technical and management assistance to small and mid-size businesses were identified and documented. NIST has done an effective job in this area, and in generating networks of contacts that will be useful in later phases of its programs. With the assistance of the National Governors Association, a survey instrument was developed and circulated for establishing a comprehensive database on state technology programs and sent to 450 people in 50 states.

The Committee will report in more detail on other aspects of the new NIST assignments in subsequent reports.

3.4. Future Concerns.

Under the Advanced Technology Program created by the Trade Act, the Director of NIST, acting for the Secretary of Commerce, is authorized to provide start-up funding for joint industrial research and development ventures, and to enter into a variety of other contractual and cooperative agreements with industry, in areas where the Institute has scientific or technical expertise. Adequately funded and well managed, the program could have a substantial positive impact on U.S. industrial competitiveness. The Committee suggests, however, that the funding and contractual aspects of the program might be better assigned directly to the Under Secretary for Technology, rather than to NIST. In addition to relieving NIST of the burden of non-technical work in which it does not have special competence, this arrangement would elevate the stature of the Advanced Technology Program. Implementation of the program under this plan would still be carried out by NIST. We will study this matter further in 1989.

## 4. NIST Budget and Resources.

### 4.1. Present Shortfall.

The Committee is deeply concerned about the shortfall in the 1989 NIST budget. Such budgetary problems exact a cost, in terms of the damage to morale and to research programs. Continued difficulties in obtaining the funds needed to sustain ongoing programs and launch new ones inevitably lead to the loss of top researchers. Many of the senior researchers at NIST have made careers there, despite the opportunities for greater personal financial reward elsewhere, because of the stimulating research environment and the opportunities for professional satisfaction and growth. These highly motivated scientists and engineers are very sensitive to cuts in funds for the equipment, facilities, and support personnel they need to carry out their research effectively. The Committee notes with regret that some key technical personnel have decided to leave NIST during the past year.

The 1989 shortfall sends a disturbing signal to the staff at NIST and to U.S. industry that is contrary to the intent of the Trade Act. The Committee believes that it is a mistake to underfund an agency that has just been given a lead role in promoting U.S. technological competitiveness. This situation will be interpreted as a lack of commitment by the federal government to continued U.S. leadership in science, technology, and international economic competition.

### 4.2. 1990 Budget.

#### 4.2.1. Budget Initiatives.

The President's budget proposal to Congress for Fiscal Year 1990 includes requests for funding in several emerging technology areas. The Committee endorses funding for all of these areas, described below.

The lightwave measurement technology initiative ($2.6 million) will provide measurement technology and services that will promote the growth of fiber optic communications systems, a new technology with enormous potential economic impact. This is an area in which the United States must maintain technical leadership for economic as well as national security reasons.

The bioprocess engineering initiative ($2.3 million) will enable NIST to development reliable measurement techniques and data to support the engineering design, scale-up, and optimal control of biochemical manufacturing processes. This initiative is an appropriate activity for NIST, which has already taken an active stance in biotechnology with the Center for Advanced Research in Biotechnology (CARB), a cooperative effort among NIST, the University of Maryland, and Montgomery County, Maryland.

High temperature superconductors are among the most widely-hailed new technologies of the 1980s. Successful development of these materials promises dramatic energy savings and development of new devices and technologies. Commercial applications with

potentially-great economic value include faster electronic circuits, virtually loss-free electricity transmission, magnetically levitated trains, and faster computers. The high temperature superconductivity initiative ($0.7 million), an incremental addition to the $2.8 million initiative funded in 1988, is certainly needed to assist U.S. industry in maintaining its strong position in that technology. However, we note that the small size of this initiative and other recent developments outside NIST do not constitute the strong federal support for this technology that was expected following the White House Symposium on High Temperature Superconductors in July 1987.

High performance composites provide superior engineering properties such as high strength, stiffness, and light weight necessary for advances in a variety of technologies. Polymer-based composites have already had a significant impact in the marketplace, and metal- and ceramic-matrix composites have large potential markets in aerospace and other technologies. The high performance composites initiative ($1 million) will expand NIST's development of measurement methods and standards to develop a science base that will assist industry in manufacturing composites and using them in new applications.

An initiative in chemical measurements and standards ($2.1 million) will fund work on detecting individual chemicals and separating complex mixtures. The program, including generic technology with application to a wide range of industrial problems, has been strongly endorsed by analytical laboratory managers of leading U.S. corporations and will support industry efforts to improve the quality assurance of chemical measurements.

NIST has proposed a computer security initiative ($3.5 million) to carry out programs in developing and implementing computer security techniques in the federal civilian government. This initiative will allow NIST to respond to the assignments it was given under the Computer Security Act of 1987, as discussed in Section 2.3.1.

As the Nation's principal measurement science and engineering laboratory, the Institute requires state-of-the-art computing capability. At present, however, the demand for computing at NIST exceeds the capability of existing equipment. To meet present and future needs, NIST has proposed a modular, flexible system as a cost effective approach. The scientific computing upgrade initiative ($3.1 million) will allow NIST to begin acquiring the equipment needed to build the upgraded system.

4.2.2. Recommendation.

Fiscal Year 1989 will be a difficult year for NIST, as discussed above. The Committee recommends that sufficient funds should be appropriated for Fiscal Year 1990 to relieve the current financial difficulties at NIST and to fund the 1990 initiatives in full. Funding should also be provided to continue operation of the regional centers for the transfer of manufacturing technology that were established in early Fiscal Year 1989.

4.3. Historical Budget Trends.

The Committee is well aware that Congress has been strongly supportive of NIST. Congressional support for the Building Technology and Fire Research programs in recent

years, for example, has been essential to their continued existence. The expanded role Congress has given NIST in advancing U.S. technological competitiveness indicates that Congressional support for NIST continues to be strong.

However, NIST's ability to carry out its mission under appropriated funds has clearly eroded in the last decade. If the extramural grants program of NIST is excluded, Congressional appropriations for Scientific, Technical, and Research Services have been roughly constant. These appropriations for 1988 were, in constant dollars, only three percent higher than in 1980. However, the cost of research has risen much faster than the general cost of living during the last decade, particularly due to the high costs of equipment and facilities, as discussed in Section 2.7.

As a result of the imbalance between costs and appropriated funds, NIST in recent years has had to derive an increased fraction of its support by pursuing funding from other agencies. Between 1982 and 1988, funding support from other agencies increased by about 40 percent in constant dollars. In Fiscal Year 1988, other agency support represented over 35 percent of total NIST funding. While some degree of outside funding is desirable, because it prompts NIST to broaden its technical skills and maintain an awareness of national technical priorities, a balance between appropriated funds and contract support is necessary.

We are concerned about NIST's need to obtain an increasing percentage of its support from other agencies for two reasons. First, NIST vulnerable to the whims and the fortunes of other agencies, since much of the NIST contract support comes from defense-related activities that will be under scrutiny in the new Administration. Second, and equally important, such outside funding can have an adverse impact on NIST's ability to carry out its core mission as stated in the Trade Act. Other agencies provide funds for NIST to carry out research to meet their objectives. In some cases, the aims of the two agencies may be compatible and even mutually beneficial. However, the need to raise increasing amounts of money through research contracts diminishes the selectivity that NIST can exercise in accepting new projects. The Committee will study the criteria NIST uses for seeking other agency funding and will monitor the balance of funding in the future.

4.4. Directed Appropriations.

Implementation of the new technology transfer activities at NIST will make the Institute a granting agency to a greater extent than it has been in the past. These activities could involve significant appropriations. The Committee is concerned that those funds be used with maximum effectiveness.

Clearly, the best way to award science and technology grants is through a competitive system based on merit reviews by technical experts. Scarce research and development money should be awarded on the basis of competence to those institutions and individuals who can demonstrate that they have creative ideas and the expertise to carry their proposed programs through to fruition.

"Directed appropriations," earmarked by legislation for specific uses and recipients, do not rely on the merit review process nor do they fulfill legislative intent. Furthermore, earmarked funds merely to be passed along by NIST deny the Institute the authority to manage and carry out programs that meet its standards. The Committee believes that directed appropriations are an inappropriate way to allocate research funds. We share this opinion with National Science Foundation Director Erich Bloch and others in the scientific and industrial communities who have also stressed the need for Congress and the scientific community to rely on merit review. Directed appropriations are contrary to the concept of Quality in research and diminish the Authorization Committee process.

4.5. Future Needs.

The Administration and Congress must work together to make federal funding of civilian technology a high priority on the Nation's agenda if high quality scientists and engineers are to be motivated to work in this area and programs are to be established that make significant contributions to U.S. industrial competitiveness. At present, our spending on research and development for defense and space far outstrips that on civilian technology. Clearly, our federal research priorities must be re-examined. The Committee encourages the federal government to provide the resources for real growth to the National Institute of Standards and Technology to fulfill its mandate under the Trade Act to provide leadership in developing technology that meets national needs.

## Visiting Committee on Advanced Technology of the National Institute of Standards and Technology

**1988**

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Mr. WALGREN. Thank you, Mr. Manly. We appreciate that testimony.

As I know, you seem in sympathy with, and we are disappointed that the Advanced Technology Program did not catch the attention of the Administration thus far, and we are hopeful that this won't just fall into the category of things we would like to do, but our wallet may not be big enough.

I got a kick out of Herb Stein who was talking about the President's statement that the will is there, but our wallet isn't, and he felt that while the reverse was true, the wallet is there, but the will isn't. I hope that we could together impress on the Administration the importance of the Advanced Technology Program and the contributions that they could make to our economic future.

Does the Visiting Committee—can you tell us a little bit about your assessment of the the Advanced Technology Program and how does the Board approach that and would they be in a position to make specific recommendations that this is a matter of high priority and ought to be funded?

Mr. MANLY. Mr. Chairman, yes. Well, first, we speak about that in our report, and the report is on the way through the Department of Commerce to the Congress, and we speak about that in this report.

Secondly, as I mentioned, Mr. Bement, the Vice Chairman of the Committee will be appearing before your Committee tomorrow, and most of his remarks are aimed at the Advanced Technology Program. But the Committee has looked at this and spent considerable time with researchers and staff at the Institute in speaking about the program.

We concur that it would be extremely wise to fund this and fund it well, but we also have an underlying problem. We would not like to see the basic part of the Institute not receive the proper funding and be moving from here into the Advanced Technology Program. You seed the scientific and technology base to the things that you're speaking about.

Mr. WALGREN. Well, I'm sure you would find very wide support for that. Our problem is that we can't get an Administration to recommend doing what needs to be done. That's reminds me of Prairie Home Companion and the shy person's relying on powdered milk biscuits to give them the strength to do what needs to be done. I would hope that in both the Visiting Committee and throughout the Administration that we would find people coming forward to advocate the necessity of taking these kinds of steps and not because we just want to, but because we need to.

I noticed in your statement that you presumed that the President's 1990 budget contained no funds for these activities out of a commitment not to kill the goose that lays the golden eggs, that is not to starve NIST's laboratory and basic functions. I would only like to say that I hope you're right, that that's why anybody would say they wouldn't kill the goose that lays the golden eggs.

The problem is that that statement has usually been made to justify keeping the government out because the government somehow or other is impinging on the private sector, and that is not at all the case in this area, and I would hope that those arguments would not be being made by people.

Mr. MANLY. There are many areas in which I think American industry would welcome this type of support, the field of advanced ceramics, the field of superconductivity, several areas in which there must be a very good cooperation between the government laboratories and American industry. As I mentioned in my opening statement, I have been spending the past three years of my life trying to do that at the Oak Ridge National Laboratory with various degrees of success.

Mr. WALGREN. One of the things that is so striking to me is that every time people accept responsibility or actually get involved in looking at the government laboratory effects and try to feel the responsibility for making the best contribution to the national interest that could be made through that kind of effort, they come away feeling that what is missing is a sense of legitimacy in the Federal science effort as government funded.

John Young, who Chaired the Task Force on Competitiveness, came back saying that what has to be established is really the acceptability of government funding and effort in these areas, not that it has to be a hundred percent, but clearly it has to be an enabling factor. We keep running up against this philosophy that the government should not be doing that.

Mr. MANLY. Mr. Chairman, I would like to speak to that, if I may. I can remember early in my career when I was at Oak Ridge National Laboratory there was very much a feeling at the laboratory that those terrible, dirty people out there in industry that are trying to make a profit were bad people, and there was not the openness on the part of those laboratory people to want to work with American industry.

As a result of the various initiatives, men changed about how to use the technology in the government laboratories, and I would say now the members of the Oak Ridge National Laboratory and other national laboratories under the Department of Energy are quite willing to work and work hard with American industry.

Now the one laboratory that by their very nature from its start has been the Bureau or now the Institute that has had this ability to work with American industry and it was not a thing that American industry felt anything came from the laboratory was bad or culturally they shouldn't work with the laboratory. There has been a long tradition that American industry has worked very closely with the Bureau and now the Institute.

Therefore, it seems to me that the Institute is the ideal laboratory to lead the way in which there is a cooperative experience between the scientific and technology people in the government laboratories and American industry. That's why I think it's so well that we do everything we can to fund this and do a job so that the Institute can truly take it's place in transferring technology out to American industry.

Mr. WALGREN. I guess I'm fishing for some way that the civilian side of the Federal Government can be recognized as being in a position to make a critical contribution to the development of a wide range of new technologies. It seems that we have gone through these 25 years with the philosophy being to really hold down the civilian side of government and the Bureau struggling to make a

good contribution, but its charter really only reaching, research and measuring and this sort of thing in the not-too-distant past.

Then we look back and here is DARPA having had to jump in with both feet into sematech, into superconductivity, into high-definition television, and they are really nothing more than a bucket of money.

Mr. MANLY. That's right.

Mr. WALGREN. And they admit that the reason they are able to do it is because they have the resources. I think by implication the reason a wider range of our society has not participated is because we didn't put the resources there to draw them out.

Now it would seem to me that one of the strengths which we believe our society has is the diversity of the private sector, and that seems to be very different than some of the very strict channeled approach of the military, and that if we want to lead with our strengths, we ought to be leading with a civilian agency that would be able to at least draw forth some focused effort in these areas rather than doing nothing and then having the military have to come in and essentially plug holes in the dike that might be most important for the military, which we naturally would want to do, but which cannot be sensitive to the broad range of possibilities for a civilian economy.

Mr. MANLY. I agree with you. I think there are a lot of people in American industry that would be much more willing to work with the civilian laboratory and civilian part of the government than they would with the Department of Defense.

Mr. WALGREN. Well, I would just like to give you the opportunity to comment on what NIST can contribute as opposed to DARPA and what we lose when we focus our efforts solely through a military research agency as opposed to a civilian research agency.

Mr. MANLY. As I say, you're going to hear testimony on that tomorrow from Mr. Bement who has taken that as part of his job.

If you take a look at one that has come up, like high-definition television that has come up and there is considerable discussion about this, I believe there that one of the biggest things that's going to be is to develop the proper standards which we are going to apply in the United States. I believe there is where the Bureau or the Institute has a considerable responsibility to find the standards which we are going to accept in the United States. With the United States controlling the largest single market in the world for this, it seems wise that we do this and do it rather quickly.

I was heartened by the fact to see that AT&T and Zenith have joined forces. Once again, where did they go? They go to the Department of Defense because they've got more money.

Mr. WALGREN. Thank you very much.

Mr. Campbell.

Mr. CAMPBELL. Thank you, Mr. Chairman.

A question to follow up just on HDTV interests me very much. The funding function I think ought to be analyzed separately from the standards setting function, and you've spoken to the standards setting function and the need to move on that quickly.

Does the Visiting Committee or you yourself, sir, have a point of view as to the funding? Is there a need for funding to get us started in HDTV, government funding, or is there the potential of having

that funded by industry itself, particularly if they are allowed to pool their resources?

Mr. MANLY. On this particular thing, I think the big thing would be for the Bureau or the Institute to work on the standards and let actually the development of the hardware and things like that be in the hands of American industry.

Mr. CAMPBELL. I appreciate that response. Going to the previous topic, you mentioned SEMATECH a couple of times and the involvement of DARPA in it. Does the Visiting Committee have a view about the funding from the Defense Department and from DARPA has had a negative influence in the effectiveness or direction of SEMATECH?

Mr. MANLY. Would you say that again.

Mr. CAMPBELL. Yes, sir. Is it your judgment or that of your Visiting Committee that the funding mechanism through DARPA or the Defense Department for SEMATECH sematech has had a negative influence?

Mr. MANLY. We as a Committee have not discussed this, but from a personal standpoint, I would like to beg the question a little bit and go back to something I've had a little experience in, and that is take high-performance ceramics as a thing that is very, very important. I have spent the last three years of my life working with the national laboratories and trying to get that information out to American industry.

The biggest thing the industry would like is to have a way to get a proven market. They would like to have a market out there that is sufficient that they can afford the luxury to spend the R&D dollars and the development dollars to be able to get this.

If you take a look at the difference we do compared to say the Japanese, I think happens what happens with MITI and the way Japan does it, they do more or less define a market size and guarantee a market size so there can be this risk money spent. This is I think one of the biggest things that we do not do as well as we should, and that's where the government's role comes in, to help to define a market and guarantee a market so that the risk money can be spent to do this.

Mr. CAMPBELL. If I could follow up just in the area of SEMATECH. Let's speak about the one megabyte dynamic random access memory chip, or the building block for the new personal computer generation. I don't think there is any doubt that a market exists for the one megabit D ram. So to put a point on my question and picking up my previous one, I am doubtful as to whether there is a need for Federal funding to do the MITI kind of function that you describe there. I'm sure that there is a support for Federal funding, but I'm asking you whether that MITI kind of function needed to be done let's say in that one instance?

Mr. MANLY. I really don't know the answer to that.

Mr. CAMPBELL. If I may, to follow up on one other area, and that's the CFCs, the chloroflurocarbons, we have a commitment by President Bush to elimination of CFCs by 2000. Do you have an opinion that you could share with us on the progress being made to substitute for CFCs and what the proper role ought to be for government in that?

Mr. MANLY. In one of our previous meetings at the Institute we were briefed by the researchers about the substitutes for the chloroflurocarbons and we were advised that there were various and sundry companies that had submitted samples to them for testing that could be the future type of materials that could be used that would do away with the problem or minimize the problem.

During the testimony of Ray Kammer and his people today, I'm sure that Dr. Lyons could go into more detail on that question for you because it is under Dr. John Lyons.

Mr. CAMPBELL. My last question, Mr. Chairman, with your indulgence, just to draw for us the prospect of the development of the federal role in technology standards setting under present conditions, I am very interested in private market alternatives to the extent that the government doesn't provide them. Standards setting organizations have sprung up in other instances, Underwriters Laboratory, for example, or in the chemistry field as well.

I wonder if you could speak to the possibility of the private standards setting operation developing as a substitute for governmental?

Mr. MANLY. Well, there are a lot of examples where there are standards, as you have already mentioned, by the Underwriter Laboratories and things of that nature. However, if you take a look at the things that the Institute does, the type of standards that we are now dealing with involve extremely unique pieces of scientific equipment to do this and unique capabilities of people. I would say that certain devices that the Institute is using to develop standards today, those are one-of-a-type pieces of equipment there. And, therefore, I think that is a role that has got to be practiced at the Institute.

Mr. CAMPBELL. Thank you very much.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Campbell.

The Chair recognizes the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

Welcome again, Bill. I wanted to just follow up on some of the questions that the Chairman and the gentleman from California started with, and that is the role of the Federal Government in promoting private sector collaboration and creating synergisms within the private sector and the role of the Advanced Technology Program. You mentioned that tomorrow Arden Bement is going to comment on that, but it seems that as Chairman of the NIST Board there would be some comment from you on the importance of this and how we can get from where we are at zero funding to where we need to be with some resources in this program.

Can you comment further on that?

Mr. MANLY. Well, Congressman Ritter, once again I guess I will go back to something I know more about, and that's working at another national laboratory. If you take a look at advanced ceramics and you make a comparison between that, and one of the advanced technologies we talked about is high performance materials, there are several things that can be done in the Federal Government. One is to push to the frontiers of knowledge and the other is to have unique facilities.

One of the things you are going to hear about in Ray's testimony today, one of the things is the cold neutron source. These unique facilities that exist in the various national laboratory are now what are called user facilities. They have been made available to American industry and they can actually do proprietary research with these facilities, and I believe those are the sort of things that the Federal Government can do more and more.

The other thing that can be done and that has been done by the Argonne National Laboratory and Oak Ridge National Laboratory and it's done by the Institute is work in consortia. I think you can carve out various and sundry areas of scientific and technology research in which you could take portions of the Institute and some of the know-how there and some of the intellectual properties and put it in the consortia and get private capital and move some of this technology out.

I think more and more this is the sort of thing that will have to be done, because when you talk about moving technology, the best way to move technology is move the people and move it with them.

Mr. RITTER. Given the potential that HDTV will be a major factor in the technology debate this year, and our bill went in last Thursday, and we have the hearings tomorrow and the day after in the Telecommunications and Finance Subcommittee. The response to the comprehensive bill has been that generally that's what is going to happen, there is going to be an HDTV initiative. Do you feel comfortable right now that the Commerce Department would be capable of coordinating and being a lead agency in such an initiative? Do you feel that NIST and the Advanced Technology Program is ready to make its contribution?

Mr. MANLY. Yes, I believe it is ready to make its contribution.

Mr. RITTER. As a coordinative body?

Mr. MANLY. I believe it can handle that function, yes. If you look at the Under Secretary for Technology, which could be the focal point for civilian technology, and let it be handling the grants, in other words, if you're going to send money out for civilian technology, let the granting agency be in the Department of Commerce under the Under Secretary, and let the Institute be the technical review of such a program, and I think you've got the capability to do this.

Mr. RITTER. People say that the reason the programs, such as SEMATECH, go to DARPA is because DARPA has the money, but also DARPA has the personnel to play this role of team-builder.

Mr. MANLY. Don't forget the Institute has only had this responsibility for roughly a year. It takes a while to get staff moved up and things of that nature.

Mr. RITTER. Has the Visiting Committee reviewed NIST's reorganization plan and the Advanced Technology Program operations proposals?

Mr. MANLY. The answer is yes, we have, Congressman, and it's in our report to the Department of Commerce to come to you.

Mr. RITTER. I'm concerned also about the pay policy. I know we have made some innovations that have helped and we have made the system more flexible in going out and getting to people. We have made the award system internally more flexible up to a cap, but I'm concerned about the cap. As I see manufacturing and some

of these industrial technology efforts in industry just taking off like rockets, I'm concerned that we're going to get the best people in the NIST and that we're going to keep the very excellent people that we have.

Has any consideration been given to——

Mr. MANLY. The answer to that is yes. We speak to the staff at every meeting about turnover and about the morale of the people and things of that nature. And don't forget the Institute did have the opportunity to have some relief under the pay and they have the kind of experimental look at the salary policies. The last time we talked to them about this it seemed to be going and going well.

Mr. RITTER. Are we still though concerned about the caps, in other words, the flexibility exists.

Mr. MANLY. The answer is yes, you do get worried about the caps.

Mr. RITTER. And is it possible that we could lose a substantial number of people in the next several years if something isn't done, particularly with the Congressional pay raise dead in the water?

Mr. MANLY. I would defer to Ray Kammer to answer this in some detail who is going to be appear in front of you, but my personal opinion is there are unique people that spend their time with the Institute. Those people are dedicated scientific people and, sure, pay is important to them, but I think it's a secondary issue with them.

Mr. RITTER. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Ritter.

The Chair recognizes Mr. Henry.

Mr. HENRY. Thank you, Mr. Chairman.

Mr. Manly, as you might expect, I, too, my questions focus on the portion of your testimony pertaining to the Department as a civilian technology advocate.

Mr. MANLY. Right.

Mr. HENRY. It has been a long and ongoing struggle between this Committee and some of the other Committees in Congress really trying to push in the direction of technology application, and that is not in any way an attempt to diminish or not recognize the traditional role of NIST or the Bureau. But I think our concerns are obvious from other questions in terms of what our immediate concerns are.

You mention, of course, some of the funding problems, that it's hard to do these things if, in fact, the money isn't there without forfeiting the traditional function of the agency, and I think it's clear that there is a commitment here to get the funding available for the traditional role of the agency as well as the new roles being ascribed to it.

But as an outside visitor, as Chairman of that panel, I guess I really have some rather direct questions I would like to put to you relative to your impressions on the new roles assigned to NIST.

No. 1, and very directly, is it your belief that the Department of Commerce at the top is fully committed to the new expanded role definitions of the agency?

Mr. MANLY. Well, that's hard for me to judge. I would say that the last member or high-level person we met is Secretary Verity. Our Committee meets with the Secretary once a year. Last year we

had the opportunity to meet with Verity twice since he was out at the Institute for opening up a new facility there. I would say our dealing with Secretary Verity, I would say that he definitely felt strongly about this.

I have yet to meet the new Secretary. We the Committee have gone on record to talk about the replacement for Dr. Ambler. We sent a letter with a list of suggested names for someone to be the new Director of the Institute, and as yet we have not received a reply to that.

We sent our report in, and I'm sure that at our next meeting, which will be in Washington in July—we will not meet the Secretary until September. By that time I hope there will be considerable changes, like a new Under Secretary for Technology and some things done about a new Director for the Institute and a reply back from our report.

Mr. HENRY. In your conversations with former Secretary Verity, was there any expression of anguish on his part in terms of the budget negotiations going on between the Department, the White House and OMB in terms of the budget proposals which were clearly underway at the time of your discussions? Did he single out his concerns in terms of underfunding which might prohibit the Department from assuming its new functions or, on the other hand, did he seem aggressive in terms of trying to get funding recognizing the new functions we're ascribing to the agency?

Mr. MANLY. I would say that since I have been on the Committee we have always been impressed, I'll use that word, with the ability to—well, Secretary Brown was the one that we dealt with primarily on the question of the budget, and I would say that we felt quite pleased with the way he defended the role of the Bureau or the Institute now for getting money.

Mr. HENRY. But specifically in terms of it's new expanded transfer functions.

Mr. MANLY. My point is we have not really met and discussed that except with Secretary Verity. At the particular time we met, it was kind of a swan song time. So I do not remember any discussions about the budget at that time, Congressman Henry.

Mr. HENRY. Let me move down in terms of Dr. Ambler. Is it your judgment that Under Secretary Ambler has been fully and firmly committed to the new task of the agency?

Mr. MANLY. The answer to that is yes. As of no later than this morning I talked to Ernie about that, and I believe he is firmly committed to that. My only concern about that is Ernie has made up his mind that he wants to retire from government service at the end of this particular month. I think the opportunities I had to meet with him and talk with him about what he's doing, I'm quite impressed with what he has been doing in pulling these various functions together and talking about what the role of the Under Secretary for Technology should be. I sincerely hope that in the near future we'll have someone to replace him.

Mr. HENRY. Do you feel just as confident as we move down to Mr. Kammer in terms of his commitment to the expanded role and function?

Mr. MANLY. I would say that Ray Kammer and Mr. Johnson and Mr. Lyons and the various people at the Institute I've met are fully

committed to do a job under the new Trade Act. I might say, if anything, the Committee might have been responsible for not going further in an organizational change, which we speak to in our report.

Mr. HENRY. I'm going to get to that next.

Mr. MANLY. We felt it was unwise to go too far in the reorganization when you were going to be bringing a new Director in. We felt that you should make those moves necessary to handle the various functions that the Institute has, but await the final reorganization until such time as the person who was going to have the responsibility to run the Institute was there to be a party of those particular organizational changes.

Mr. HENRY. The reason I have asked my questions is, as you know, there is suspicion in many circles that the Department at the top is very supportive of some of our concerns, but the closer you get to the bowels of the agency, the more institutional resistance there is. That's not casting people in good or bad light, but it's simply saying in terms of resistance to change organizationally, and I think what is an inherent, and disdain is too strong a word, but separate role definition from pure science and applied science. You understand thoroughly that we are friends of the agency, and yet we are very concerned about this role mission.

You mention in your testimony on this point that you were involved in advising and reviewing organizational changes in the organizational plan. What particular changes then did you see that are explicitly directed to implementing the new duties? What changes have been made and what further changes do you believe are necessary organizationally in the Institute?

Mr. MANLY. Well, the first one was to appoint Dr. Johnson for his job and to have those various responsibilities there. There was also considerable readjustment and realigning so that you would minimize the various and sundry Departments and Sections and try to bring these various Departments that relate to each other closely together. There was considerable discussion about intellectual property patents and licensing and things of that nature and how the organization at the top, whether these various and sundry functions were there, like the Budget Office and the intellectual properties and the technology transfer and things of that nature. How they reported into the top means an awful lot because the way people look at an organizational chart in a lot of ways depends upon the way they relate to that particular organization. So we did consider that.

We also, as I had mentioned, did caution them and suggested that we do not make some other changes that I'm sure eventually will be made until such time when they do have a new Director, because the choice of people and how well they are going to function together I think should be the responsibility of the new Laboratory Director.

Mr. HENRY. If I move from the organizational chart and the linkages and the description of the agency as it might reflect itself in organizational changes into the personnel policies of the agency, are rates of compensation comparable relative to the key researchers of the agency on the pure science side and those on the technology transfer side?

Mr. MANLY. The answer is yes.

Mr. HENRY. Given the fact that the stipulated role of the agency has now been formally changed, have the personnel evaluation mechanisms within the agency been formally changed to reflect on personnel recordkeeping evaluations based, among other things, on explicit criteria relative to success not only in the traditional role of the agency, but in terms of assisting the agency in its new task? Has there been any change in the personnel evaluation process?

Mr. MANLY. I personally do not know that, and I would pass the question to Mr. Kammer. I would say the Committee in its deliberations with Mr. Kammer did suggest that the way you judge somebody in technology transfer and some of the things where you're very close to working with industry will be a lot different than the way you judge a person doing long-hair research in a laboratory.

Mr. HENRY. What I'm wondering though is whether or not that issue has become a question of personnel evaluation review?

Mr. MANLY. I do not know the detail of that, and I suggest you ask Mr. Kammer that in his testimony.

Mr. HENRY. Then, finally, I can anticipate what the testimony of the agency is going to be. In fact, one of the reasons I can anticipate it is because it's before me and I can read it, but other than fulfilling direct legislative authorization and appropriation in the development of three new technology transfer centers and indicating in somewhat anecdotal fashion, although appropriately so, how the basic research has applied to users who contract with the agency, the cold neutron facility being an example and an exciting one that we wait for its full development and implementation, but did you sense in terms of previous visits to the agency any sense of aggressively marketing technology transfer as opposed to simply being available to request from major corporations that have preexisting ties to the agency? Was there a sense of change of spirit in the agency in any way?

Mr. MANLY. The answer is yes. I'm very impressed by the way they stepped up to the challenge that was given to them to do this and the way they have worked with the various State agencies and the things they have done with the Federal laboratories. I have been quite impressed by how, with not a lot of financial support, they have been able to do a lot of readjustment at the Institute to address these particular things that you're asking. I'm impressed by it, I really am, and this is something, to be able to move in the thing is a slow process to do this because you're changing, and not only you have to change, but the attitude of people out there, the marketplace also has to change its attitude about you, and I have been impressed by this.

Mr. HENRY. I yield to the Chairman.

Mr. WALGREN. The gentleman's time has expired.

The Chair would recognize the gentleman from Iowa, Mr. Nagel.

Mr. NAGEL. Thank you, Mr. Chairman.

Coming to the bottom line, I gather that the flexible freeze in the President's budget does not appeal to you as it applies to these programs.

Mr. MANLY. That is true. I was leafing through my testimony here, and I mentioned the fact that it would only take one airplane

to be able to do an awful lot to change the budget for the civilian technology part that we're speaking about today.

Mr. NAGEL. I guess as a Member sitting here and on the Space Committee, I don't know how we get competitive if we are not willing to pay for programs such as you're advocating here. But noting your decision, your testimony here, the Committee is unanimous in its conclusion the new technology transfer activities, not matter of important, must not be funded at the expense of existing of future science and engineering programs at NIST. You see, I don't know how you get there without revenue, and I'm waiting for some witness to come up here and say, you know, Mr. Nagel, we need new revenues in government and the flexible freeze isn't going to work in this program and it isn't going to work in a host of government programs. If we're going to be competitive, we're got to pay for it.

Mr. MANLY. I think I said here that we are concerned that they cannot respond to the expectations of you and the Institute itself and American industry, and the only way it can be done is if there is some way that they get the additional funding.

Mr. NAGEL. Would that be to maybe raise taxes?

Mr. MANLY. It's not up to me to say. You can't raise it by selling standards. [Laughter.]

Mr. NAGEL. I don't have any quarrel with your testimony. I thought you remarks were very well taken, but it is frustrating while we operate, at least for this Member, while we operate around here under the illusion that we are not going to raise revenues and we're going to have a flexible freeze on programs such as the ones you're advocating are going in the tank. You know, I think we're living in an illusion that, unfortunately, may last for another year. I think we need revenues and I think we have to raise those revenues to fund the kind of programs you're advocating.

Mr. MANLY. I said on page 7 of my testimony "The entire yearly budget of the Institute would not purchase a single advanced defense aircraft," and I think that something to think about.

Mr. NAGEL. I saw that.

Thank you.

Mr. WALGREN. Thank you, Mr. Nagel.

Mr. Ritter.

Mr. RITTER. Mr. Chairman, I just want to make one comment. There has been some discussion of DARPA. I guess I would love to see a repository in the Federal Government that handles some of these issues of cutting edge technology and putting the industrial players together. I really think the time is now to push for it within the Department of Commerce. HDTV could well be the cutting edge.

Regarding DARPA, though, I think, thank God it has been there, because if it wasn't there, there would be a whole host of things, the things that were mentioned by the gentleman from California and other things that would never have happened, and they are lean and mean and they spend their money quickly out in industry. They are non-bureaucratic and they do deserve plenty of accommodation considering their achievements, but we need something else outside of the military.

Mr. MANLY. But, Congressman, and I agree with you wholeheartedly, but you've got to look at one thing. If you look at DARPA as like a new products generator in a corporation, and a corporation has a big R&D laboratory, it has a new products group and then it has got a normal organization, if you make an analysis between that and what goes on, it would seem that DARPA is defining the new products, and out here is DOD, the Army and the Navy. So it's where these things are going to go. That's the one thing that is not abundantly clear to me that now has been built into this.

I mean you've got the Institute to do the basic research and you've got American industry doing basic research, you've got the Under Secretary having a role there to coordinate all this, but there is not some place that you've got a new products area that's like a holding tank, so to speak, to get it ready to go out to the American industry.

Mr. RITTER. I think you're absolutely right. I also think that more and more we're talking about process. Manufacturing is a process, and the eventuality and the generation of new products is largely becoming a function of process and the sophisticated interaction of people and technology. I think it's this long-term process focus, which for American industry and government combined has largely been ignored in the past several decades, and it's here where Commerce can take this long-range view, because in many way we are never going to get to those products unless we pay a lot more attention to the process.

Mr. MANLY. I agree with that, Congressman. But also, don't forget, it has not only been ignored by government, but it has been ignored by academia and everything. Don't forget that in our field the process metallurgist was poor boy and the guy that developed the new products was the one that was getting all the hero awards. Fortunately, things have now changed and the process metallurgist is now getting his heyday.

Mr. RITTER. If you look at the Japanese, so many of their new products have come out directly from long-term focus on process.

Mr. WALGREN. Let me understand, was your analogy to DARPA as being the element that defined new products?

Mr. MANLY. It takes the needs that the DOD see out there and defines it back, and that's a hard role that I see that is going to have to be played.

Mr. WALGREN. Now who would play that role?

Mr. MANLY. I think you're going to take each one separately. I think some of them the basic research is going to be in the Institute and some the basic research is going to be outside, and maybe here is where a consortia could go together and define this is a product we want to have, and they would be the holding tank or the incubator for this thing to happen until it's ready to go out to the marketplace.

Mr. WALGREN. Certainly that's true. In our original exploring of a new organization for NIST we had this concept of an Advanced Technology Board which essentially, as I remember, would have had the responsibility to define those directions for those products. Now the Visiting Committee is in that position. Is the Visiting Committee the proper makeup to define that function for NIST?

Mr. MANLY. I would say the function that I'm speaking about is almost an eight-hour-a-day, 24-hour or five or six days a week thing. They can act as an advisory board, but you have to have people doing this all the time and living with it day and night.

Mr. WALGREN. So presently you do not see anywhere in the NIST structure an entity that can fill that function that you saw DARPA as doing with respect to the military defining the products and defining the direction.

The Visiting Committee I interpret much as the board of a college, for example, which oversees a president and an administration, but it doesn't really define with sharp edge the direction that the technology efforts take.

Mr. MANLY. It could define a sharp edge of where the technology is going, but I think we're talking about how you take the technology and make a product or a final process out of it, and I have a hard time believing that this can be done on a three or four meetings a year basis.

Mr. WALGREN. Well, thank you very much, Mr. Manly. We appreciate your contribution to our process and we look forward to talking with you informally as the situation arises.

Our second panel, Dr. Ambler, the Director of the Institute for so many years, but now Acting Under Secretary of Commerce for Technology; Dr. Joseph Caponio, the Director of the National Technical Information Service and Ray Kammer, the Acting Director of the National Institutes of Standards and Technology.

Let me say at the outset, as I'm sure all in the room know in a small community, that Dr. Ambler will be retiring at the end of this month or perhaps the end of next, whichever, but quite soon after serving 15 years as the Director of the Bureau of Standards and then as NIST was created becoming the Acting Under Secretary of Commerce for Technology.

I want to on behalf of myself and certainly as a Representative of all that I represent, and I know for many other Members, express our appreciation of all you have done in those 15 years. Those have been very interesting years in which the concept of the Bureau has been changing and certainly we have seen under your direction much put in place that we now hope to build on for the future.

When you think back on the old Bureau and it's a very different place, and we on behalf of the national interest appreciate all that you have contributed to that. It's a substantial part of a whole career to be 15 years as the Director of an Institute on this level in our system, and I'm sure that's very gratifying to you and your service is very much appreciated by all of us.

Dr. AMBLER. Thank you very much, Mr. Chairman.

Mr. WALGREN. Let's turn to the testimony then today. We'll start with Dr. Ambler and then continue in order in which I introduced you to the record.

We are pleased you're here and we invite you to give your views in whichever fashion you see fit.

I hope sometime you might get the chance to make a farewell statement for the record, Dr. Ambler. This may not be exactly the right time, but it will be interesting to think of a time that you might do that. Certainly you have a tremendous range of institu-

tional knowledge, and you've seen so much happen at the Bureau. You've seen both the possibilities and the limitations of the system that we have, Congressional limitations and Congressional possibilities.

So we look forward to hearing much from you in the future, but we would like to recognize you now for your testimony today.

## STATEMENT OF DR. ERNEST AMBLER, ACTING UNDER SECRETARY OF COMMERCE FOR TECHNOLOGY

Dr. AMBLER. With your permission, I will go through my written testimony, but just touch on the highlights and ask that the full testimony be included in the record.

I am pleased to be here to testify on the mission activities and the fiscal year 1990 authorization request for the Technology Administration.

By reporting out legislation last year establishing the Under Secretary for Technology and the Technology Administration within the Department of Commerce, this Subcommittee has helped make some vital changes in the Federal Government's ability to deal with technology issues, and especially the civilian technology matters that are so important to our economic vitality.

I believe this is a critical step in highlighting the role of technology within the Department of Commerce and in integrating that role with a considerable economic analysis, trade and other functions of the Department.

The decision to emphasize technology in the Commerce Department is logical. What other Federal agency has so uniquely the mission of supporting business, industry and the economy? The addition of an Under Secretary for Technology at Commerce not only recognizes the importance of technology in the overall business and economic picture, but it also affords a basis for concentrating our efforts on subjects that demand a longer-range view.

We are all very much aware that this organizational adjustment takes place at the same time that the Department of Defense has voiced strong concerns that the United States industrial base may be inadequate to support our national security objectives.

Since becoming Acting Under Secretary in early December of last year, I have been working in principally four areas laying the groundwork for this operation.

First, I have been setting up the Office of the Under Secretary, reviewing ongoing programs and setting some priorities.

I have also been examining the considerable efforts by other Commerce agencies to work with and on behalf on business and industry, and this includes those offices directly responsible for trade, export and economic affairs.

When I took this job I made talking with industry and organizations outside the Department a top priority. I wanted to be sure that the Under Secretary's Office would set out its mission and its activities in a way that was most useful for technology-based industry in this country. I am pleased to report that we have received the support of some key organizations for the approach we are taking.

Before I cover the last area on which I have concentrated, namely, trying to come to grips with what we mean by civilian technology policy, let me now describe the actions we have taken in setting up the Technology Administration as a result of my planning, examination of Commerce Department programs, and discussions with industry, and I'll also review our fiscal year 1990 authorization request.

The mission of the Under Secretary and the Technology Administration is to develop and promote Federal technology policies and programs to increase U.S. commercial and industrial innovation productivity and growth through consultation and collaboration with United States industrial and non-profit sectors.

The Office of the Under Secretary is a catalyst, a friend, a forum, a listening post and a voice in Washington for technology-based industry. It is a voice for civilian technology concerns in the government generally.

There are three line organizations within the Technology Administration: the National Institute of Standards and Technology, the National Telecommunications and Information Administration and the National Technical Information Service. A description of the missions and key activities of these agencies and of the new Technology Administration Offices is included in the fact sheet which I have attached to this testimony, although I think this Committee scarcely needs that to keep them informed about the line organizations.

The two new offices in the Technology Administration are the Office of Technology Policy and the Office of Commercial Affairs. The enabling legislation established the Assistant Secretary for Technology Policy as the head of a Policy Analysis Office, and the Policy Analyst for the Under Secretary. Many of the programs which the former OPTI had begun will continue under these two offices. These new offices also include groups dealing with Federal laboratory technology transfer, the Japanese Technical Literature Act and strategic materials resources.

The role of the Policy Analysis Office is to:

Identify opportunities or barriers affecting the United States commercial innovation, quality, productivity and manufacturing, and then to advocate Federal policies and programs to eliminate those barriers;

To consult and collaborate with the industrial and non-profit sectors in a variety of ways in order to identify priority technologies, analyze our foreign competitors' progress in technology and identify underlying scientific and infrastructure support that would assist in the development and commercial deployment of these technologies;

To assist state, local and regional organizations in their support of technology-oriented companies through a clearinghouse with information on the initiatives and experience of those organizations to date.

In contrast, the Office of Commercial Affairs has more operational programs. The role of this office is to:

Encourage the establishment of industry research consortia through joint ventures, including R&D limited partnerships;

Help to speed the adoption of flexible computer-integrated manufacturing by small and medium-sized industry;

Increase private sector access to Federally-developed technology;

Improve the information available to United States companies about Japanese science and technology developments, including the analysis of trends in Japan and translations of Japanese technical literature; and

Work closely on technology issues with the Department of Defense, which is particularly concerned about the defense industrial base.

To assure that industry has a regular platform for addressing civilian technology issues within the Department and the Federal Government at large, I have drafted a charter for an Advisory Board with predominant industrial membership, and this Board I hope will become a central feature of the operations of the Under Secretary.

For fiscal year 1990 the President is requesting a total of $4.1 million for the Technology Administration. This funding would cover the immediate Offices of the Under Secretary, the Office of Technology Policy and the Office of Commercial Affairs. Separate authorization requests have been submitted for two of the line organizations of the Technology Administration, NIST and NTIA. NTIS is self-funding, and therefore no authorization request is made.

The Committee has expressed special interest in several activities called for in the Omnibus Trade and Competitiveness Act of 1988 and carried out by the Under Secretary for Technology's Offices.

I address these items in my written statement, and additional information on this Office's responsibilities under the Trade Act and our enabling legislation is included in the second attachment to my testimony. I think I have been through the bill fairly carefully and listed the assignments to the Technology Administration.

After a few months on the job, I can tell you that setting up an organization to deal with technology policy and United States competitiveness turns out to be the easy part of the job. To determine exactly what the Federal Government's role should be, however, still is not crystal clear to me, and I would submit in light of some of the discussion that has preceded me here, not clear to a lot of other people either.

It's an exaggeration, but useful for argument's sake, to say that there are two extreme and opposing positions. You have those who are somewhat xenophobic and try to whip everybody into a frenzy over sharing any information with other countries and over investment by other countries in the United States. They want the Federal Government to take action, take control and do it now.

The other side says that we should let nature take its course. If there is a foreign technology competition, that's all to the good and there is no need for any government involvement. They are saying don't worry, let the marketplace decide. It's a question of survival of the fittest.

Well, as is usually the case when dealing with extreme positions, there is some merit on both sides, but there is one thing I think

which is absolutely incontrovertible, and that is, it is the job of the private sector to develop and sell goods and services. The government has never been successful in showing industry how to do its job and there is absolutely no reason to think that is going to change in the future.

That does not mean that the Federal Government cannot help. It can. Working with the private sector as a partner, the government's role is to ensure a fair playing field in the international marketplace, an environment in which other governments play a major role. But the government's role must be limited and carefully designed to help and not to hinder.

Business and industry must get out front and they must do so in a way that is more cohesive from a national point of view. I want to stress this point about industry taking the lead because it is basic to the way in which the Technology Administration, in my opinion, should be conducting its business. I want to make it clear that this new government organization is no substitute for more aggressive industry action.

High-definition television is a critical technology and it's timely to give it our attention. Here we have questions about a technology, technical standards and the prospect of $100 billion market. Already the Japanese have taken the lead demonstrating the possibilities this technology holds for the consumer and for companies which are positioned to take advantage of the technical opportunities. They seem to have a national business plan.

In the United States the issue is joined with the broadcast, cable, telephone, electronics computer and defense sectors all engaged in a struggle to get Federal policy to recognize their own legitimate points of view. The national interest is not always the main focus of this debate among competing sectors. That is the government's responsibility and we have to try and get a consensus.

The Federal Government cannot and should not make the critical decisions about which technical path to pursue in order to bring about business success. That's industry's job.

This country is facing a huge challenge in getting to the global marketplace first with the newest, highest- quality technology available. The challenge comes not just from the Japanese, but from the Koreans and others, including the now unifying Europeans. The creation of this new technology organization within the Department of Commerce is a positive step towards meeting those challenges. I think that the mechanism is now in place for a Department of Commerce that will be more aggressive, more in tune with industry's technology needs and more capable of serving the country.

Thank you, Mr. Chairman. That's the end of my statement, and I'll be very glad to answer any questions you may have.

[The prepared statement of Dr. Ambler follows:]

TESTIMONY BY DR. ERNEST AMBLER
ACTING UNDER SECRETARY FOR TECHNOLOGY
BEFORE THE
HOUSE SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
ON TECHNOLOGY ADMINISTRATION
FISCAL YEAR 1990 AUTHORIZATION

MARCH 7, 1989

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE:

I AM PLEASED TO BE HERE TODAY TO TESTIFY ON THE MISSION, ACTIVITIES, AND FISCAL YEAR 1990 AUTHORIZATION REQUEST FOR THE TECHNOLOGY ADMINISTRATION.

THESE HEARINGS COME AT A TIME WHEN THE COMMERCIALIZATION OF TECHNOLOGY IS GETTING UNPRECEDENTED ATTENTION FROM THE CONGRESS, THE ADMINISTRATION, INDUSTRY AND THE COUNTRY AS A WHOLE.

BY REPORTING OUT LEGISLATION LAST YEAR ESTABLISHING THE UNDER SECRETARY FOR TECHNOLOGY AND THE TECHNOLOGY ADMINISTRATION WITHIN THE DEPARTMENT OF COMMERCE, THIS SUBCOMMITTEE HAS HELPED MAKE SOME VITAL CHANGES IN THE FEDERAL GOVERNMENT'S ABILITY TO DEAL WITH TECHNOLOGY ISSUES -- ESPECIALLY THE CIVILIAN TECHNOLOGY MATTERS THAT ARE SO IMPORTANT TO OUR ECONOMIC VITALITY.

I BELIEVE THAT THIS IS A CRITICAL STEP IN HIGHLIGHTING THE ROLE OF TECHNOLOGY WITHIN THE DEPARTMENT OF COMMERCE, AND IN INTEGRATING THAT ROLE WITH THE CONSIDERABLE ECONOMIC ANALYSIS, TRADE AND OTHER FUNCTIONS OF THE DEPARTMENT.

SECRETARY MOSBACHER, IN HIS SENATE CONFIRMATION HEARINGS, SAID THAT THE ROLE OF THE UNDER SECRETARY FOR TECHNOLOGY "IS AN EXTREMELY HIGH PRIORITY" AND THAT HE WAS CONCERNED ABOUT U.S. CAPABILITIES IN HIGH-TECHNOLOGY AREAS. THE SECRETARY HAS EMPHASIZED THE NEED FOR INDUSTRY AND GOVERNMENT ACTIONS TO BOOST THESE CAPABILITIES.

THERE IS WIDESPREAD CONCERN OVER THE STATE OF CIVILIAN TECHNOLOGY IN THIS COUNTRY -- AND, MORE PRECISELY, THE COMMERCIALIZATION AND RATE OF APPLICATION OF TECHNOLOGY TO THE ECONOMY. IT IS AN ISSUE THAT WE MUST DEAL WITH BETTER BECAUSE OF ITS IMPORTANCE TO ECONOMIC GROWTH AND OUR COMPETITIVE POSITION. OUR WORLD TECHNOLOGY LEADERSHIP HAS BEEN CHALLENGED AND CAN NO LONGER BE TAKEN FOR GRANTED.

THE DECISION TO EMPHASIZE TECHNOLOGY IN THE COMMERCE DEPARTMENT IS LOGICAL. WHAT OTHER FEDERAL AGENCY HAS SO UNIQUELY THE MISSION OF SUPPORTING BUSINESS, INDUSTRY AND THE ECONOMY? THE ADDITION OF AN UNDER SECRETARY FOR TECHNOLOGY IN COMMERCE NOT ONLY RECOGNIZES THE IMPORTANCE OF TECHNOLOGY IN THE OVERALL BUSINESS AND ECONOMIC PICTURE. IT ALSO AFFORDS A BASIS FOR CONCENTRATING OUR EFFORTS ON SUBJECTS THAT DEMAND A LONGER-RANGE VIEW.

WE ARE ALL VERY MUCH AWARE THAT THIS ORGANIZATIONAL ADJUSTMENT TAKES PLACE AT THE SAME TIME THAT THE DEPARTMENT OF DEFENSE HAS VOICED STRONG CONCERNS THAT THE U.S. INDUSTRIAL BASE MAY BE INADEQUATE TO SUPPORT OUR NATIONAL SECURITY OBJECTIVES.

SINCE BECOMING ACTING UNDER SECRETARY IN EARLY DECEMBER OF LAST YEAR I HAVE BEEN WORKING IN PRINCIPALLY FOUR AREAS, LAYING THE GROUNDWORK FOR THIS OPERATION.

FIRST, I HAVE BEEN SETTING UP THE OFFICE OF THE UNDER SECRETARY, REVIEWING ONGOING PROGRAMS, ESPECIALLY THOSE THAT ARE DERIVED FROM THE AUTHORITY OF THE STEVENSON-WYDLER TECHNOLOGY INNOVATION ACT, AND SETTING SOME PRIORITIES.

I ALSO HAVE BEEN EXAMINING THE CONSIDERABLE EFFORTS BY OTHER COMMERCE AGENCIES TO WORK WITH AND ON BEHALF OF BUSINESS AND INDUSTRY. THIS INCLUDES THOSE OFFICES DIRECTLY RESPONSIBLE FOR TRADE, EXPORT AND ECONOMIC AFFAIRS. I HAVE CONCLUDED THAT THERE ARE MANY ONGOING ACTIVITIES IN THE DEPARTMENT THAT CAN BE TAPPED TO PUT US IN A STRONGER POSITION TO DEAL WITH TECHNOLOGY ISSUES. I ALSO HAVE BEEN IMPRESSED BY THE POSITIVE ATTITUDE IN OTHER PARTS OF THE DEPARTMENT TO HELP THE TECHNOLOGY ADMINISTRATION.

WHEN I TOOK THIS JOB, I MADE TALKING WITH INDUSTRY AND ORGANIZATIONS OUTSIDE THE DEPARTMENT A TOP PRIORITY. I WANTED TO BE SURE THAT THE UNDER SECRETARY'S OFFICE WOULD SET OUT ITS MISSION AND ITS ACTIVITIES IN A WAY THAT WAS MOST USEFUL FOR TECHNOLOGY-BASED INDUSTRY IN THIS COUNTRY. I AM PLEASED TO REPORT THAT WE HAVE RECEIVED THE SUPPORT OF SOME KEY ORGANIZATIONS FOR THE APPROACH WE ARE TAKING.

BEFORE I COVER THE LAST AREA ON WHICH I HAVE CONCENTRATED -- TRYING TO COME TO GRIPS WITH WHAT WE MEAN BY "CIVILIAN TECHNOLOGY POLICY" -- LET ME NOW DESCRIBE THE ACTIONS WE HAVE TAKEN IN SETTING UP THE TECHNOLOGY ADMINISTRATION AS A RESULT OF MY PLANNING, EXAMINATION OF COMMERCE DEPARTMENT PROGRAMS, AND DISCUSSIONS WITH INDUSTRY. I ALSO WILL REVIEW OUR FISCAL YEAR 1990 AUTHORIZATION REQUEST.

THE MISSION OF THE UNDER SECRETARY AND THE TECHNOLOGY ADMINISTRATION IS: "TO DEVELOP AND PROMOTE FEDERAL TECHNOLOGY POLICIES AND PROGRAMS TO INCREASE U.S. COMMERCIAL AND INDUSTRIAL INNOVATION, PRODUCTIVITY AND GROWTH THROUGH CONSULTATION AND COLLABORATION WITH U.S. INDUSTRIAL AND NON-PROFIT SECTORS." THE OFFICE OF THE UNDER SECRETARY IS A CATALYST, A FRIEND, A FORUM, A LISTENING POST AND A VOICE IN WASHINGTON FOR TECHNOLOGY-BASED INDUSTRY. IT IS A VOICE FOR CIVILIAN TECHNOLOGY CONCERNS IN THE GOVERNMENT GENERALLY.

THERE ARE THREE LINE ORGANIZATIONS WITHIN THE TECHNOLOGY ADMINISTRATION -- THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, THE NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION, AND THE NATIONAL TECHNICAL INFORMATION SERVICE. A DESCRIPTION OF THE MISSIONS AND KEY ACTIVITIES OF THESE AGENCIES AND OF THE NEW TECHNOLOGY ADMINISTRATION OFFICES IS INCLUDED IN THE FACT SHEET WHICH IS ATTACHED TO THIS TESTIMONY.

THE TWO NEW OFFICES IN THE TECHNOLOGY ADMINISTRATION ARE THE OFFICE OF TECHNOLOGY POLICY AND THE OFFICE OF COMMERCIAL AFFAIRS. THE ENABLING LEGISLATION ESTABLISHED THE ASSISTANT SECRETARY FOR TECHNOLOGY POLICY AS THE HEAD OF A POLICY ANALYSIS OFFICE AND THE "POLICY ANALYST FOR THE UNDER SECRETARY." MANY OF THE PROGRAMS WHICH THE FORMER OPTI HAD BEGUN WILL CONTINUE UNDER THESE TWO OFFICES. THESE NEW OFFICES ALSO INCLUDE GROUPS DEALING WITH:

- FEDERAL LABORATORY TECHNOLOGY TRANSFER (INCLUDING IMPLEMENTATION OF THE STEVENSON-WYDLER TECHNOLOGY INNOVATION ACT OF 1980 AND THE FEDERAL LABORATORY TECHNOLOGY TRANSFER ACT OF 1986),
- THE JAPANESE TECHNICAL LITERATURE ACT, AND
- STRATEGIC MATERIALS RESOURCES.

THE ROLE OF THE POLICY ANALYSIS OFFICE IS TO:

- IDENTIFY OPPORTUNITIES OR BARRIERS AFFECTING U.S. COMMERCIAL INNOVATION, QUALITY, PRODUCTIVITY AND MANUFACTURING, AND THEN TO ADVOCATE FEDERAL POLICIES AND PROGRAMS TO ELIMINATE THOSE BARRIERS. FOR EXAMPLE, WE ARE PAYING SPECIAL ATTENTION TO THE ISSUE OF CHANGES TO EXPANSION OF THE R&E TAX CREDIT AND THE POSSIBLE RELAXATION OF ANTITRUST LAW SO THAT COOPERATIVE MANUFACTURING VENTURES ALSO WOULD BE POSSIBLE.

- CONSULT AND COLLABORATE WITH THE INDUSTRIAL AND NON-PROFIT SECTORS IN A VARIETY OF WAYS IN ORDER TO IDENTIFY PRIORITY TECHNOLOGIES, ANALYZE OUR FOREIGN COMPETITORS' PROGRESS IN TECHNOLOGY AND IDENTIFY UNDERLYING SCIENTIFIC AND INFRASTRUCTURE SUPPORT THAT WOULD ASSIST IN THE DEVELOPMENT AND COMMERCIAL DEPLOYMENT OF THESE TECHNOLOGIES.

- ASSIST STATE, LOCAL AND REGIONAL ORGANIZATIONS IN THEIR SUPPORT OF TECHNOLOGY-ORIENTED COMPANIES THROUGH A CLEARINGHOUSE WITH INFORMATION ON THE INITIATIVES AND EXPERIENCES OF THESE ORGANIZATIONS TO DATE. I WILL DISCUSS THE STATUS OF THE CLEARINGHOUSE LATER IN MY TESTIMONY.

IN CONTRAST, THE <u>OFFICE OF COMMERCIAL AFFAIRS</u> HAS MORE OPERATIONAL PROGRAMS. THE ROLE OF THIS OFFICE IS TO:

- ENCOURAGE THE ESTABLISHMENT OF INDUSTRY RESEARCH CONSORTIA THROUGH JOINT VENTURES, INCLUDING R&D LIMITED PARTNERSHIPS.

- HELP TO SPEED THE ADOPTION OF FLEXIBLE COMPUTER-INTEGRATED MANUFACTURING BY SMALL- AND MEDIUM-SIZED INDUSTRY. THIS INCLUDES PROMOTING A CONCEPT WHEREBY COMPANIES CAN SHARE AUTOMATED PRODUCTION FACILITIES.

- INCREASE PRIVATE SECTOR ACCESS TO FEDERALLY-DEVELOPED TECHNOLOGY BY SEEKING GREATER INDUSTRY INVOLVEMENT IN, AND AWARENESS OF, RESEARCH CONDUCTED AT FEDERAL LABORATORIES.

- IMPROVE THE INFORMATION AVAILABLE TO U.S. COMPANIES ABOUT JAPANESE SCIENCE AND TECHNOLOGY DEVELOPMENTS, INCLUDING THE ANALYSIS OF TRENDS IN JAPAN AND TRANSLATIONS OF JAPANESE TECHNICAL LITERATURE.

- WORK CLOSELY ON TECHNOLOGY ISSUES WITH THE DEPARTMENT OF DEFENSE, WHICH IS PARTICULARLY CONCERNED ABOUT THE DEFENSE INDUSTRIAL BASE.

- REPRESENT U.S. COMMERCIAL INTERESTS IN INTERNATIONAL SCIENCE AND TECHNOLOGY AGREEMENTS AND FORUMS, IN COOPERATION WITH THE INTERNATIONAL TRADE ADMINISTRATION.

TO ASSURE THAT INDUSTRY HAS A REGULAR PLATFORM FOR ADDRESSING CIVILIAN TECHNOLOGY ISSUES WITHIN THE DEPARTMENT AND THE FEDERAL GOVERNMENT AT LARGE, A CHARTER HAS BEEN DRAFTED FOR AN ADVISORY BOARD WITH PREDOMINANT INDUSTRIAL MEMBERSHIP. THIS BOARD WILL BE A CENTRAL FEATURE OF THE OPERATIONS OF THE UNDER SECRETARY.

FOR FISCAL YEAR 1990, THE PRESIDENT IS REQUESTING A TOTAL OF $4.1 MILLION FOR THE TECHNOLOGY ADMINISTRATION. THIS FUNDING WOULD COVER THE IMMEDIATE OFFICES OF THE UNDER SECRETARY, THE OFFICE OF TECHNOLOGY POLICY, AND THE OFFICE OF COMMERCIAL AFFAIRS. SEPARATE AUTHORIZATION REQUESTS HAVE BEEN SUBMITTED FOR TWO OF THE LINE AGENCIES OF THE TECHNOLOGY ADMINISTRATION -- NIST AND NTIA. NTIS IS SELF-FUNDING, AND THEREFORE NO AUTHORIZATION REQUEST IS MADE.

THIS COMMITTEE HAS EXPRESSED SPECIAL INTEREST IN SEVERAL ACTIVITIES CALLED FOR IN THE OMNIBUS TRADE AND COMPETITIVENESS ACT OF 1988 AND CARRIED OUT BY THE UNDER SECRETARY FOR TECHNOLOGY'S OFFICES.

OUR OFFICE OF TECHNOLOGY POLICY IS WORKING ON THE CLEARINGHOUSE FOR STATE AND LOCAL INITIATIVES ON PRODUCTIVITY, TECHNOLOGY AND INNOVATION. CALLED FOR IN THE TRADE ACT, THIS CLEARINGHOUSE SHOULD BE A VALUABLE CENTRAL RESOURCE FOR DATA ON THESE STATE AND LOCAL PROGRAMS AND INITIATIVES, AND FOR SHARING SUCCESSFUL EXPERIENCES. THUS FAR, WE HAVE FOCUSED ON MAKING SURE THAT WE HAVE A COMPREHENSIVE UNDERSTANDING ABOUT WHAT SOURCES OF INFORMATION ALREADY EXIST, EXACTLY WHAT INFORMATION THE STATES NEED FOR THE CLEARINGHOUSE TO BE SUCCESSFUL, AND HOW IT SHOULD BE OPERATED. WE HAVE IDENTIFIED SEVERAL TYPES OF STATE AND LOCAL ACTIVITIES AS POSSIBLE CANDIDATES TO BE COVERED BY THE CLEARINGHOUSE. THESE INCLUDE ENTERPRISE ZONES, VENTURE CAPITAL, INCUBATORS, TECHNICAL TRAINING, AND MANUFACTURING AUTOMATION EFFORTS.

TO SPEED THE PROCESS AND HELP GET THE JOB DONE MOST EFFECTIVELY, WE HAVE ENTERED INTO AN AGREEMENT WITH THE ADVISORY COMMISSION ON INTERGOVERNMENTAL RELATIONS. WE ALSO HAVE BEEN TAKING ADVANTAGE OF INFORMATION FROM NIST AND THE NATIONAL GOVERNORS ASSOCIATION REGARDING STATE-BASED TECHNOLOGY DEVELOPMENT ACTIVITIES. FOUR WORKSHOPS WILL BE CONDUCTED THIS SPRING WITH REPRESENTATIVES OF STATE AND LOCAL GOVERNMENTS, BUSINESSES, CONGRESSIONAL STAFFS, FEDERAL AGENCIES, AND PUBLIC INTEREST GROUPS. THE WORKSHOPS WILL HELP US DECIDE THE BEST WAY TO RUN THE CLEARINGHOUSE.

THE TRADE ACT ALSO ASSIGNED THE DEPARTMENT CERTAIN RESPONSIBILITIES RELATING TO FEDERAL AGENCIES' USE OF THE METRIC SYSTEM. AS PART OF ITS RESPONSIBILITIES, THE OFFICE OF COMMERCIAL AFFAIRS ENCOURAGES BUSINESS AND INDUSTRY TO ADDRESS METRIC CONVERSION AS IT RELATES TO U.S. COMPETITIVENESS. TO CARRY OUT THE TRADE ACT'S ASSIGNMENTS, WORKING THROUGH AN INTERAGENCY COMMITTEE, WE HAVE BEEN ASSISTING OTHER AGENCIES TO PLAN FOR THEIR USE OF METRIC. THE ACT CALLS FOR THESE AGENCIES TO USE METRIC IN THEIR PROCUREMENT, GRANTS AND OTHER BUSINESS-RELATED ACTIVITIES, WHERE FEASIBLE, BY LATE 1992. WE ARE DEVELOPING GUIDELINES TO FACILITATE THIS CONVERSION.

THE TRADE ACT ALSO DIRECTED THE DEPARTMENT TO RESTART THE COMMERCE, SCIENCE, AND TECHNOLOGY FELLOWSHIP PROGRAM TO ENABLE SCIENTISTS, ENGINEERS AND OTHERS FROM AROUND THE FEDERAL GOVERNMENT TO WORK ON SPECIAL ASSIGNMENTS IN OTHER FEDERAL OFFICES. WE HAVE DEVELOPED A PLAN FOR CARRYING OUT THE PROGRAM; THE PLAN WILL BE TRANSMITTED TO CONGRESS AFTER IT IS REVIEWED WITHIN THE ADMINISTRATION.

ADDITIONAL INFORMATION ON THIS OFFICE'S RESPONSIBILITIES UNDER THE TRADE ACT AND OUR ENABLING LEGISLATION IS INCLUDED IN THE SECOND ATTACHMENT TO MY TESTIMONY.

AFTER A FEW MONTHS ON THE JOB, I CAN TELL YOU THAT SETTING UP AN ORGANIZATION TO DEAL WITH "TECHNOLOGY POLICY" AND U.S. COMPETITIVENESS TURNS OUT TO BE THE EASY PART OF THE JOB. DETERMINING EXACTLY WHAT THE FEDERAL GOVERNMENT'S ROLE SHOULD BE, HOWEVER, IS STILL NOT CRYSTAL CLEAR.

IT IS AN EXAGGERATION, BUT USEFUL FOR ARGUMENT'S SAKE, TO SAY THAT THERE ARE TWO EXTREME AND OPPOSING POSITIONS. YOU HAVE THOSE WHO ARE SOMEWHAT XENOPHOBIC AND TRY TO WHIP EVERYONE INTO A FRENZY OVER ANY SHARING OF INFORMATION WITH OTHER COUNTRIES AND OVER ANY INVESTMENT BY OTHER COUNTRIES IN THE UNITED STATES. THEY WANT THE FEDERAL GOVERNMENT TO TAKE ACTION, TAKE CONTROL, AND DO IT NOW.



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THE OTHER SIDE SAYS THAT WE SHOULD LET NATURE TAKE ITS COURSE. IF THERE IS FOREIGN TECHNOLOGY COMPETITION THAT IS ALL TO THE GOOD, AND THERE IS NO NEED FOR ANY GOVERNMENT INVOLVEMENT. THEY ARE SAYING, "DON'T WORRY, LET THE MARKETPLACE DECIDE; IT IS A QUESTION OF SURVIVAL OF THE FITTEST."

WELL, AS IS USUALLY THE CASE WHEN DEALING WITH MOST EXTREME POSITIONS, THERE IS SOME MERIT IN EACH CASE. BUT THERE IS ONE THING WHICH I THINK IS INCONTROVERTIBLE. IT IS THE JOB OF THE PRIVATE SECTOR TO DEVELOP AND SELL GOODS AND SERVICES. GOVERNMENT HAS NEVER BEEN SUCCESSFUL IN SHOWING INDUSTRY HOW TO DO ITS JOB, AND THERE IS ABSOLUTELY NO REASON TO THINK THAT WILL CHANGE IN THE FUTURE.

THAT DOES NOT MEAN THAT THE FEDERAL GOVERNMENT CANNOT HELP. IT CAN. WORKING WITH THE PRIVATE SECTOR AS A PARTNER, THE GOVERNMENT'S ROLE IS TO ENSURE A FAIR PLAYING FIELD IN THE INTERNATIONAL MARKET PLACE, AN ENVIRONMENT IN WHICH OTHER GOVERNMENTS PLAY A MAJOR ROLE. BUT THE GOVERNMENT'S ROLE MUST BE LIMITED AND CAREFULLY DESIGNED TO HELP AND NOT TO HINDER.

BUSINESS AND INDUSTRY MUST GET OUT FRONT, AND THEY MUST DO SO IN A WAY THAT IS MORE COHESIVE FROM A NATIONAL POINT OF VIEW. I WANT TO STRESS THIS POINT ABOUT INDUSTRY TAKING THE LEAD, BECAUSE IT IS BASIC TO THE WAY IN WHICH THE TECHNOLOGY ADMINISTRATION WILL BE CONDUCTING ITS BUSINESS. I WANT TO MAKE IT CLEAR THAT THIS NEW GOVERNMENT ORGANIZATION IS NO SUBSTITUTE FOR MORE AGGRESSIVE INDUSTRY ACTION.

HIGH-DEFINITION TELEVISION, OR HDTV, IS A CRITICAL TECHNOLOGY WHICH SERVES AS A TIMELY CASE IN POINT. HERE WE HAVE QUESTIONS ABOUT A TECHNOLOGY, TECHNICAL STANDARDS, AND THE PROSPECT OF A 100 BILLION DOLLAR MARKET. ALREADY THE JAPANESE HAVE TAKEN THE LEAD, DEMONSTRATING THE POSSIBILITIES THIS TECHNOLOGY HOLDS FOR THE CONSUMER AND FOR COMPANIES WHICH ARE POSITIONED TO TAKE ADVANTAGE OF THE TECHNICAL OPPORTUNITIES. THEY SEEM TO HAVE A NATIONAL BUSINESS PLAN. IN THE UNITED STATES, THE ISSUE IS JOINED, WITH THE BROADCAST, CABLE, TELEPHONE, ELECTRONICS, COMPUTER, AND DEFENSE SECTORS ALL ENGAGED IN A STRUGGLE TO GET FEDERAL POLICY TO RECOGNIZE THEIR OWN LEGITIMATE POINTS OF VIEW. THE NATIONAL INTEREST IS NOT ALWAYS THE MAIN FOCUS OF THIS DEBATE AMONG COMPETING SECTORS. THAT IS THE GOVERNMENT'S RESPONSIBILITY AND WE HAVE TO TRY TO GET A CONSENSUS. THE FEDERAL GOVERNMENT CANNOT AND SHOULD NOT MAKE THE CRITICAL DECISIONS ABOUT WHICH TECHNICAL PATH TO PURSUE IN ORDER TO BRING ABOUT BUSINESS SUCCESS. THAT IS INDUSTRY'S JOB.

THIS COUNTRY IS FACING A HUGE CHALLENGE IN GETTING TO THE GLOBAL MARKETPLACE FIRST WITH THE NEWEST, HIGHEST-QUALITY TECHNOLOGY AVAILABLE. THE CHALLENGE COMES NOT JUST FROM THE JAPANESE, BUT FROM THE KOREANS AND OTHERS -- INCLUDING THE UNIFYING EUROPEANS. THE CREATION OF THIS NEW TECHNOLOGY ORGANIZATION WITHIN THE DEPARTMENT OF COMMERCE IS A POSITIVE STEP TOWARD MEETING THOSE CHALLENGES. I THINK THAT THE MECHANISM IS NOW IN PLACE FOR A DEPARTMENT OF COMMERCE THAT WILL BE MORE AGGRESSIVE, MORE IN TUNE WITH INDUSTRY'S TECHNOLOGICAL NEEDS, AND MORE CAPABLE OF SERVING THE COUNTRY.

MR. CHAIRMAN, I WOULD BE HAPPY TO ANSWER ANY QUESTIONS YOU MAY HAVE. THANK YOU.

U.S. Department of Commerce
Washington, D.C. 20230

# Under Secretary for Technology & the Technology Administration

### ❖ Why were the Under Secretary for Technology and the Technology Administration established?

The international marketplace has changed dramatically. Technology has become a much more important factor in the world trading picture; it is the watchword for the economy as we approach the 1990's. The United States no longer has an unquestioned lead in the development and manufacture of high-technology products. Other countries have been adapting and adopting technologies first invented in the United States. Now these countries also are aggressively developing new technologies on their own. The Japanese clearly have taken the lead in many high-technology products, with the Koreans and others also demonstrating their strengthened abilities. A newly unified European economy which builds upon sophisticated technical capabilities promises additional challenges for American industry.

Today's global market realities demand not only the creation of new technologies–at which America continues to excel–but the rapid and continuous conversion of this technological know-how into new commercial products, services, and markets. Technology-based industry needs a focal point in the Federal Government, an advocate for government policies and actions that will speed technology transfer and remove barriers to the commercialization of new technologies by industry.

That is why a new position of Under Secretary for Technology and a Technology Administration have been established. The Commerce Department–the federal agency that deals most directly with business and industry–now has a broad and coordinated range of programs to help improve U.S. competitiveness.

### ❖ How will this new arrangement improve upon the previous Commerce Department structure?

With a central focus on technology, the Under Secretary is in a unique position to work with other parts of the Commerce Department and the Federal Government that aim to remove barriers and provide incentives to the rapid deployment of technology in the United States. The Under Secretary can work closely with the President's Science Adviser and help coordinate strategies and programs with other government agencies, including the Departments of Defense, Energy, Labor, State, Education, and Treasury, as well as the National Science Foundation and the National Aeronautics and Space Administration.

The new organization provides a central point for those in academia, business, and government who share a common goal: the creation, production, and commercial success of technology-based U.S. goods and services. The new arrangement helps ensure that civilian technology gets the attention it deserves as the key to America's economic vitality.

### ❖ What are some of the major activities of the Under Secretary?

The Under Secretary is giving priority attention to:

- Identifying opportunities or barriers affecting U.S. commercial innovation, quality, productivity, and manufacturing.
- Advocating federal policies and programs to eliminate–across the government–statutory, regulatory, or other barriers to the rapid U.S. commercialization of science and technology.
- Consulting and collaborating with the U.S. industrial and non-profit sectors to identify priority technologies, analyze foreign competitors' progress in technology, and provide a forum for U.S. industry to discuss issues of mutual interest. This will be done in part by chartering an advisory committee on the commercialization of technology, giving industry a platform to discuss technology and competitiveness issues and an opportunity to counsel the Secretary of Commerce.
- Advising the Secretary and President's Science Adviser regarding the needs and commercial relevance of federally-funded research and development.
- Fostering and promoting federal investment in R&D, technical standards, and intellectual property protection necessary for optimal U.S. commercial development of new products and processes.
- Representing U.S. commercial interests in international science and technology agreements and forums.
- Promoting joint efforts involving business, industry, educational institutions, and state and local organizations to encourage technology commercialization.

### ❖ Which agencies make up the Technology Administration?

The new Technology Administration reporting to the Under Secretary for Technology consists of two new offices–the Office of Technology Policy and the Office of Commercial Affairs–and three existing agencies: the National Institute of Standards and Technology, the National Telecommunications and Information Administration, and the National Technical Information Service.

### ❖ What do these agencies do to help improve the technological competitiveness of U.S. industry?

***Office of Technology Policy***

This policy analysis and development organization works closely with U.S. industry and other government agencies to identify opportunities and barriers affecting U.S. commercial innovation, quality, productivity, and manufacturing. It analyzes and advocates the removal of technical and non-technical barriers to the commercialization of technology including macroeconomic policies such as antitrust, trade, product liability, tax, regulatory, and intellectual property laws. The OTP staff also evaluates civilian technology trends and commercial potential in the United States and assesses options for greater cooperation among industry, government, and academia. The Assistant Secretary for Technology Policy directs this office. Key activities include:

- Developing policy recommendations on making permanent and expanding the research and development tax credit to encourage industrial R&D and expanding it to start-up ventures.
- Developing information for use in considering the possible further relaxation of antitrust regulations that encourage joint industrial research and development activities so that cooperative manufacturing ventures also would be possible.
- Analyzing federal R&D funding and its relevance to civilian technologies, including an ongoing review of funding and policies in the President's FY 1990 budget proposal.
- Assisting state, local, and regional organizations in their support of technology-oriented companies and institutions through a clearinghouse with information on the initiatives and experiences of these organizations to date.
- Collecting and analyzing information on productivity, quality, innovation, and competitiveness.

***Office of Commercial Affairs***

Together with the Office of Technology Policy, this organization works with industry to develop a consensus regarding technology opportunities and foreign competitive challenges. OCA facilitates cooperative joint ventures with U.S. industry in areas of research and technology development, and aims to improve the ability of U.S. industry to access federally-funded technology. The office provides specific assistance in targeting and coordinating information activities in areas such as Japanese science and technology and metric conversion. Key activities include:

- Encouraging the establishment of industry research consortia through the establishment of joint ventures, including R&D limited partnerships.
- Facilitating the adoption of flexible computer-integrated manufacturing by small- and medium-sized businesses by encouraging the establishment of private sector-funded joint centers and by working with other federal agencies and industry to remove barriers and create incentives.
- Increasing private sector access to federally-developed technology by seeking greater industry involvement in, and awareness of, research conducted at federal laboratories. This includes offering policy guidance for cooperative R&D agreements and patent policies involving federal laboratories.

- Improving the information available to U.S. companies about Japanese science and technology developments, including the analysis of trends in Japan and translations of Japanese technical literature.
- Representing U.S. commerce by developing and advocating U.S. government policies, goals, and strategies in bilateral and multilateral science and technology agreements and forums.
- Encouraging business and industry to address metric conversion as it relates to U.S. competitiveness, and assisting in the Federal Government's own conversion to the metric system in its procurements, grants, and other business-related activities by late 1992.
- Managing the annual National Technology Medal, presented by the President as an incentive to individuals or companies for outstanding contributions to the promotion of technology or technological manpower for the United States.

***National Institute of Standards and Technology***

NIST is the only federal research laboratory with the mission of directly serving industry. The agency was established as the National Bureau of Standards in 1901 and re-named when it was given an expanded technology outreach mission as part of the Omnibus Trade Act of 1988. NIST is a science and engineering laboratory that specializes in measurements, standards, and technology. This work is vital to all segments of the economy to assure quality and cost-competitiveness of high-technology products and services. A non-regulatory agency, NIST works in areas ranging from automated manufacturing, electronics, and materials research to computer science and technology, building and fire research, and biotechnology. NIST increasingly focuses on the needs of U.S. industry engaged in developing and applying emerging technologies. It relies heavily on collaboration with industry, universities, and federal, state, and local organizations. Key activities include:

- Speeding the development and transfer of new methods of automated manufacturing to help U.S. industry to improve quality, modernize manufacturing processes, and ensure product reliability and cost-effectiveness.
- Providing industrial designers with information on the properties of new materials such as the recently discovered high-temperature superconductors, super-strong polymer composites, better-performing metals, and advanced ceramics for automotive and electronics applications.
- Developing new measurement methods and tools to help industry commercialize laboratory advances in fields such as biotechnology and fiber optic communications systems, and to improve the productivity of engineers in industry who get products and services to market.
- Providing the technical standards, information, and services needed to ensure national and international measurement capability and compatibility. This permits buyers and sellers of increasingly sophisticated products and services to compete fairly in the marketplace.
- Encouraging total quality management improvement in U.S. manufacturing and service firms through the Malcolm Baldrige National Quality Award program.
- Serving as a neutral, third-party expert to help industry reach consensus on measurement-intensive matters and to resolve technical disputes of national importance.

***National Telecommunications and Information Administration***

NTIA is responsible for developing federal telecommunications technology policies, and serves as the principal executive branch adviser to the President on domestic and international communications policies. This includes policies affecting common carrier, telephone, broadcast, and satellite communications systems. Directed by the Assistant Secretary for Communications and Information, the agency helps to decrease regulation and increase competition in common carrier operations. It also deals with the growing overlap between telecommunications and computers. In the information field, NTIA focuses attention on issues of privacy and security and the impact of U.S. and international privacy legislation on the flow of electronic data across national boundaries. Other key activities include:

- Conducting basic and applied research in telecommunications.
- Administering the Public Telecommunications Facilities grant program, which provides assistance to public television and radio stations.
- Developing administration policy proposals in areas such as video, telephone, and information services.
- Assigning federal radio frequency spectrum to federal agencies and establishing the Federal Government's policies relating to spectrum allocation.

In a matter of special concern to U.S. technology competitiveness, NTIA is leading efforts to establish policies governing the introduction of advanced television technologies which will provide film-like quality to viewers. These policies could affect $100 billion in investments by U.S. industry and consumers. NTIA seeks to ensure that American manufacturers and providers are given maximum opportunity to compete in this market.

***National Technical Information Service***

NTIS stimulates innovation and productivity throughout the U.S. economy by channeling the results of U.S. and foreign government-sponsored research and development and other specialized information to American industry, educational institutions, and government agencies. All operating expenses are funded through the sale of products and services. Key activities include:

- Operating an information program that serves as a central source for the sale of foreign and U.S. government-funded research, development and engineering reports, and associated business information. Nearly three million information products–computer software and data files as well as microform and paper reports–are shipped each year.
- Licensing patents on developments at federal laboratories to encourage commercialization of ideas based on government research. In 1988, 66 licenses were issued for federally-patented inventions. Investments pledged by these new licensees to commercialize the inventions totaled more than $158 million. In addition, the Federal Government received $5.6 million in royalties from past inventions.
- Providing industry and government agencies with timely information about federal laboratory research with special potential for commercialization.

### ❖ What other functions does the Under Secretary perform?

The Under Secretary represents the Secretary of Commerce on a variety of advisory and policy groups, including the Advisory Committee on Semiconductors and the National Commission on Superconductivity.

### ❖ When was the new organization established?

The Under Secretary and Technology Administration were established by legislation signed into law on October 24, 1988. Former Commerce Secretary C. William Verity appointed Dr. Ernest Ambler, who was director of the National Institute of Standards and Technology, as Acting Under Secretary on December 2, 1988.

For additional information about the Under Secretary and the Technology Administration, contact:

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February 1989

## UNDER SECRETARY OF COMMERCE FOR TECHNOLOGY

Assignments from the National Institute of Standards and Technology Authorization Act for Fiscal Year 1989

| Assignment | Legislation | Status |
|---|---|---|
| Establish the positions of Under Secretary of Commerce for Technology and Assistant Secretary for Technology Policy. The Under Secretary and Assistant Secretary are appointed by the President by and with the advice and consent of the Senate. | Stevenson-Wydler Technology Innovation Act of 1980, as Amended, Sec. 5(a). | - Technology Administration, Office of Technology Policy, Under Secretary and Assistant Secretary were established by Public Law 100-519 and reaffirmed by the Departmental Order of 1/6/89.<br>- Acting U/S Technology named 12/2/88. |
| Serve as head of the Technology Administration, manage and supervise its programs, activities and the organizational units (as specified in law -- NTIS and NIST -- or the Departmental Order -- NTIA). | Stevenson-Wydler Act, as Amended, Sec. 5(a)(1). | - Organizational assignments made final by 1/6/89 Departmental Order.<br>- Staff transfers to TA 1/15/89.<br>- Office of Technology Policy and Office of Commercial Affairs established by Departmental Order. |
| Carry out any functions assigned formerly to the Office of Productivity, Technology and Innovation. | Stevenson-Wydler Technology Innovation Act of 1980, as amended, Section 5(c)(3). | - All existing functions and staff were transferred to the Technology Administration 1/15/89. |
| NTIS, NIST, and an Office of Technology Policy are part of the Technology Administration. | Stevenson-Wydler Technology Innovation Act of 1980, as amended, Sec. 5(a)(1-3). | - The Departmental Order of 1/6/89 established these organizations, along with the NTIA in the Technology Administration. |
| The Secretary and Under Secretary, through NTIS, shall establish and maintain a program to monitor Japanese SST. | Stevenson-Wydler Technology Innovation Act of 1980, as amended, Sec. 5(d). | - Existing program transferred 1/15/89.<br>- Annual reports and directories are ongoing projects.<br>- The program is jointly planned and implemented with NTIS. |
| The Under Secretary shall assist in the implementation of the Metric Conversion Act of 1975. | Stevenson-Wydler Technology Innovation Act of 1980, as amended, Sec. 5(c)(4). | - The existing metric program has been assigned to the Office of Commercial Affairs. |

Assignments from the Omnibus Trade and Competitiveness Act of 1988

| Assignment | Legislation | Status |
|---|---|---|
| President's report to the Congress on his policies and budget proposals regarding Federal research in semiconductors and semiconductor manufacturing technology including fiber optics and optical-electronic technologies, superconducting materials, and advanced manufacturing technologies. | Omnibus Trade & Competitiveness Act of 1988 (P.L. 100-418) Section 5141. | - Executive Order to implement the Trade Act assigns responsibility to the Secretary of Commerce with assistance and policy guidance by OMB and OSTP. The Secretary has delegated responsibility to the Under Secretary for Technology.<br>- Under Secretary is coordinating with OMB and OSTP and has asked the agencies directly for information.<br>- Realistic schedule calls for the report to be submitted by August 1989. |
| The Advisory Committee on Semiconductors. | Omnibus Trade & Competitiveness Act of 1988 (P.L. 100-418); Section 5142. | - Under Secretary represents the Secretary at committee meetings. |
| The National Commission on Superconductivity. | Omnibus Trade & Competitiveness Act of 1988 (P.L. 100-418) Section 5143. | - Departmental Order delegates this responsibility to the Under Secretary.<br>- Awaiting establishment of the Commission. |
| Report within six months on a plan to implement the Commerce, Science, and Technology Fellowship Program. | Omnibus Trade & Competitiveness Act of 1988 (P.L. 100-418) Sec. 5163(d). | - Charter for program has been drafted and circulated for review and is now undergoing final revision for submission to Congress. |
| Implement the provisions of the Metric Conversion Act of 1975 for the Department of Commerce. | Omnibus Trade & Competitiveness Act of 1988 (P.L. 100-418); Section 5164. | - The metric program is working with the Interagency Committee on Metrication to establish Government-wide guidelines to implement the provisions of the Act.<br>- Notice has been submitted for the Federal Regulatory Agenda.<br>- A handbook for Federal Agencies is being prepared. |
| Establish a Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation in the Technology Administration. | Stevenson-Wydler Technology Innovation Act of 1980, as amended, Section 6. [Omnibus Trade & Competitiveness Act of 1988 (P.L. 100-418); Section 5122] | - In FY 1988, a Memorandum of Understanding negotiated with the Advisory Commission on Intergovernmental Affairs to deliver report & initial database 9/30/89.<br>- First report sent to Congress 1/89. |

Mr. WALGREN. Thank you, Dr. Ambler.

Why don't we turn to Dr. Caponio and have his testimony, and then I think we'll have a little discussion, and then turn to Mr. Kammer so that the people accompanying him from NIST will be able to join at the table and not have a tremendous crowd.

Dr. Caponio.

## STATEMENT OF JOSEPH F. CAPONIO, DIRECTOR, NATIONAL TECHNICAL INFORMATION SERVICE

Dr. CAPONIO. Thank you, Mr. Chairman and Members of the Subcommittee.

I also have submitted a formal statement for the record and, with your permission, I would like to utilize this time to address the specific questions raised in your letter inviting me to testify.

First of all, as to what steps have been taken to implement Section 212 of the NTIS Act which was passed last year. NTIS has for several decades carried out many of the basic functions detailed in the NTIS Act. We are pleased that the Act recognizes the importance of these functions. The modernization initiative will place NTIS in a much stronger position to serve the technical information needs of the government, business, industry and academic users of that vital information.

In the implementation of new methods and media for the dissemination of scientific and technical information NTIS will make electronic dissemination a major focus over the next several years because this kind of dissemination is rapidly overtaking the more traditional media of paper and microfiche. Through our own efforts, as well as through joint ventures with private firms, we plan to offer expanded products and services using new dissemination technologies, such as CD-ROM technology, electronic bulletin boards and diskettes for selected databases and abstract newsletters to supplement our traditional paper products.

Also, we are actively engaged in reviewing the recently released Office of Technology Assessment report "Informing the Nation: Federal Information Dissemination in an Electronic Age" to determine precisely how NTIS can move toward implementation of the "electronic NTIS" envisioned in that report.

As to the retention of net revenues to fund NTIS' modernization initiative, the Department's Office of General Counsel is presently reviewing the NTIS Act of 1988 to ensure that its specific language does in fact provide the revenue retention authority intended by the Congress.

Regarding the status of annual audits, we are presently working with the Department's Inspector General to arrange for the independent audit of NTIS' financial statements. We expect to include the results of this audit in the FY-1989 annual report.

Regarding the Advisory Board required by the NTIS Act, NTIS is also working with the Office of the General Counsel and other Commerce offices to develop a charter for the Board and to otherwise see that we are establishing the Board in accordance with the provision of the Advisory Committee Act. I expect its members will be in place, appointed and actively involved in reviewing and advis-

ing the Secretary on the general policies and operations of NTIS sometime this summer.

With respect to NTIS' annual reporting requirements, the reports have been prepared. I understand at this moment they have recently been approved by the Department and the Administration and will be submitted to your Committee very shortly.

And now, finally, to bring you up to date on the NTIS activities in support of Japanese Technical Literature Act. As you know, Mr. Chairman, the NTIS has been involved in the acquisition of Japanese documents for some time, and some of our accomplishments have been detailed in the statement submitted for the record.

NTIS has presently formal agreements with over 40 significant Japanese information sources which permit distribution of their technical publications in the United States. These sources in the laboratories of the Science and Technology Agency and the Ministry of International Trade and Industry, as well as industrial giants such as Hitachi, Toshiba, Toyota and others.

NTIS also offers on-line access to some of the major Japanese science and technology databases. These are are the databases which comprise the JICST Online Information Service which offer citations to articles appearing in about 7,000 Japanese science and technological periodicals.

Also, through the Scientific and Technical Reporting and Information Dissemination Enhancement Project, known as STRIDE, the Department of State and the National Science Foundation provide up-to-date information on the latest scientific and technical developments gathered by U.S. Embassy science personnel in various countries, including Japan.

This information is provided to NTIS and published in our redesigned "Foreign Technology Abstract Newsletter" and distributed weekly to subscribers.

Finally, about our role in the newly created Technology Administration. Our role will center on enhancing technology transfer and on removing those information barriers which tend to serve to delay the commercialization of new technologies by American industry.

Mr. Chairman and Members of the Subcommittee, this concludes my statement, and I'll be happy to answer any other questions you may have.

[The prepared statement of Dr. Caponio follows:]

U.S. DEPARTMENT OF COMMERCE
PREPARED STATEMENT OF JOSEPH F. CAPONIO
DIRECTOR OF THE NATIONAL TECHNICAL INFORMATION SERVICE

Before the Subcommittee on
Science, Research and Technology
Committee on Science and Technology
House
March 7, 1989

Mr. Chairman and Members of the Subcommittee, because NTIS is self-supporting, we are not requesting appropriated funding for FY 1990. However, I would like to take this opportunity to review some of our recent accomplishments, and to address the questions raised in your letter inviting me to testify.

First of all, our accomplishments:

NTIS was self-supporting in FY 1988; total revenues earned from the sale of NTIS products and services were $25 million, while costs were $24.9 million.

In FY 1988, NTIS:

- Sold approximately 400 thousand copies of documents in paper and 1.4 million in microfiche.
- Acquired and made available approximately 65 thousand (including 23 thousand foreign) new Government-sponsored technical reports.
- Prepared the 1988 Directory of Japanese Technical Resources in the United States in support of the Japanese Technical Literature program.
- Acquired approximately 1,600 reports of Japanese origin.

- Granted 66 revenue-bearing patent licenses under which licensees pledged $160 million of new investment to commercialize Government-owned inventions; filed 21 inventions in foreign countries to protect overseas marketing rights for U.S. companies; and generated revenues of $3.7 million through our licensing program.
- Initiated a program of joint ventures with private firms to assist in making results of U.S. Government R&D available to industry, business, and the general public. Four such agreements were signed with private firms and six others are in various stages of negotiation.

Further details on our FY 1988 accomplishments and operating results are included in the annual report which NTIS has prepared and which I expect you will receive in the near future.

Mr. Chairman, I would now like to address the questions raised in your letter inviting me to testify before this Subcommittee today.

As the Subcommittee knows, NTIS has for several decades, been carrying out many of the basic functions detailed in Section 212 (e) of the NTIS Act that was passed last year. We are pleased that the Act recognizes the importance of these functions. The modernization initiative will place NTIS in a stronger position to serve the technical information needs of

Government, business, industry and academic users of that vital information.

Because electronic dissemination is rapidly overtaking the more traditional media of paper and microfiche, NTIS will make this a major focus over the next several years. Through our own efforts, as well as through joint ventures with private firms, we plan to offer expanded products and services using new dissemination technologies such as CD-ROM, electronic bulletin boards, and diskettes for selected databases and abstract newsletters to supplement our traditional paper products. For example, we have completed the development phase of a new electronic bulletin board. This system will increase access to hundreds of inventions made in Federal laboratories, and will speed availability of this technical and licensing information to U.S. industry. Also, we are actively engaged in reviewing the recently released Office of Technology Assessment report "Informing the Nation: Federal Information Dissemination in an Electronic Age" to determine precisely how NTIS can move toward implementation of the "electronic NTIS" envisioned in that report. Two areas already identified for modernization are bar coding technology for inventory control and product dissemination, and new information technologies for the bibliographic control process which produces the NTIS database.

The Department's Office of General Counsel is reviewing the NTIS Act of 1988 to ensure that its specific language does, in fact,

provide the revenue retention authority intended by the Congress. This review is required before NTIS can seek appropriations to use monies collected on behalf of other agencies to fund our modernization efforts.

Last year's legislation requires an annual independent audit of NTIS' financial statements. We are working with the Department's Inspector General to arrange for the audit of NTIS' financial statements. We expect to include the results of this audit in the FY 1989 annual report.

With respect to the Advisory Board required by the new NTIS Act, NTIS is working with the Office of the General Counsel and other Commerce offices to develop a charter for the Board and to otherwise see that we are establishing the Board in accordance with the provisions of the Advisory Committee Act. I expect its members will be appointed and actively involved in reviewing and advising the Secretary on the general policies and operations of NTIS sometime this summer.

The NTIS Act further directs the Secretary to submit to the Congress an annual report which summarizes the operations of NTIS, details an operating plan, discusses modernization, and provides the result of the required annual audit. In addition, the Omnibus Trade and Competitiveness Act requires the Secretary to submit a report on fees and declining sales. As I noted earlier, these reports have been prepared and are currently being

reviewed within the Administration prior to their transmittal to Congress.

And now, to bring you up to date on NTIS' activities in support of the Japanese Technical Literature Act. As you know, NTIS has been involved in the acquisition of Japanese documents for some time, and I mentioned some of our accomplishments earlier in my statement. In addition to these accomplishments, NTIS has formal agreements with over 40 significant Japanese information sources which permit distribution of their technical publications in the United States. These sources include the laboratories of the Science and Technology Agency and the Ministry of International Trade and Industry, as well as industrial giants such as Hitachi, Toshiba, Toyota, and others. NTIS also offers an on-line access to some of the major Japanese S&T databases. These are the databases which comprise the JICST Online Information Service (JOIS) which offer citations to articles appearing in about 7,000 Japanese S&T periodicals. JOIS databases cover science and technology, medical sciences, current research in progress, Government reports, and new products and innovation. Also, through the Scientific and Technical Reporting and Information Dissemination Enhancement Project (STRIDE), the Department of State and the National Science Foundation provide up-to-date information on the latest scientific and technical developments gathered by U.S. Embassy science personnel in various countries, including Japan. This information is provided to NTIS and

published in our redesigned "Foreign Technology Abstract Newsletter" and distributed weekly to subscribers.

Finally, NTIS plans to be an active player in the newly created Technology Administration. Our role will center on enhancing technology transfer and on removing those information barriers which serve to delay the commercialization of new technologies by American industry.

Mr. Chairman, that concludes my prepared statement. I will address any questions you or other members of the Subcommittee may have.

Mr. WALGREN. Thank you very much, Dr. Caponio.

Why don't we have a little discussion and then we'll turn to Mr. Kammer at that point.

I guess my concern, Dr. Ambler, is that the Technology Administration have the power to take advantage of opportunities that it might see. I noticed in your testimony you focused on the authorizing language in there. You said that the mission of the Technology Administration is to develop and promote Federal technology policies through consultation and collaboration with U.S. industry and non-profit sectors. I guess I'm wondering what your concept, or what could the concept of those words be. Does collaboration enable us to be actors in the causing of research to happen, or does collaboration mean that all we can do is talk?

Dr. AMBLER. Well, it certainly doesn't preclude the support of research, but the aspect of the collaboration that I think is vital is that we provide a forum and provide a stimulus for industry to come together and define a way of working together in various ways to tackle some of the problems that we all perceive.

I don't think that—well, let me start that statement again. I like to think that you can decide. There are certain areas of technology, the emerging technology, and superconductivity would be one, where you can say that without a lot of consideration about the specific applications and specific companies working in the field it generally would be a good thing from a national point of view to support a more generic kind of research to provide infrastructure support.

Mr. WALGREN. Then the question I would have, and let me state it, and then you can continue with that thought and perhaps get back to, is then who would do that? Who would be deciding these emerging technologies, and not that anybody wants to be the dictator, but where would that ferment and discussion take place out of which we could take a direction?

Dr. AMBLER. Well, I do want to come to the type B, but deciding what are the emerging technologies is obvious. I mean it was two years ago that Bud Brown asked me to do a report in the Department and to list the emerging technologies and list the kinds of products or processes to which they would be applied and which kind companies they would be interested in, and we went further, and we listed the kind of barriers to their deployment. So deciding what the emerging technologies are is a thing that technical people can do fairly easily. I mean optoelectronics, for example, superconductivity is one, biotechnology and you can go on. It's really not very difficult.

And I think we all accept, and we have accepted in this country for many years that that is supported both in the private sector and by the Federal Government. I want to come to the type B because I think that is more important because we don't know now to deal with the type B things as well as we do with the type A situation. So I'm oversimplifying it a little bit.

Mr. WALGREN. Could you define type A and B again for me.

Dr. AMBLER. Well, I just defined type A. Now type B, and high-definition television would be an example of that, type B are technologies where there is a deep involvement of the private sector. There are all kinds of various interests and different points of view

and where, and I'm coming right to the point now, in trying to set civilian technology policy, it's absolutely hopeless unless you link it to economic and business policy, and I think to try to suppose that you can do that is a mistake.

Now if you would accept that, then what you find is that frequently the economic and business policies lead into political decisions. I don't use that in a pejorative way, but I use it in the best possible sense. You have to balance different interests in taking actions. So it leads you into that forum, and to think that you can develop some kind of national policy from the point of view of technology alone I think is a mistake, and I think it's a mistake we have been making.

So that's what I mean by the two types of technology.

Mr. WALGREN. All right. So you've got this list of emerging technologies and that's apparently pretty easy to come up with, and I gather there is a consensus on that among that community, but then the question comes what can we suggest to do about each of these technologies, and what I'm fishing for is what should be the role of the Under Secretary versus the—what we do we call it now, the Visiting Board? Do we call it the Visiting Board or do we call it the Visiting Board of NIST which was suggested, at least at some point, to have a very specific role in focusing on what needs to be done to advance certain technologies in the guidance I guess they give to NIST. After we identify it, where in the system can we get suggestions of what do about it?

Dr. AMBLER. Well, there is a fair amount of support being given by the government and there is support from the private sector in probably all of the areas of emerging technology. I suppose if you're looking at them and now this is for the longer range or for the infrastructure that is required, and if you were to ask how do you support that and what are your priorities and how big the support should be, that becomes really a decision of the Federal investment as a whole.

I think one of the most significant things that has happened recently in that regard occurred in the confirmation hearings of Mr. Darman, which I watched with great interest on television, and he said, speaking about the need to have our technology efforts support better the problems we're all concerned with, civilian technology and productivity and so on, he said that he would support carrying out in OMB a cross-cut review of the Federal investment in R&D and that he would do that in conjunction with the President's Science and Technology Adviser, and I think he said also the academies, I'm not quite sure.

I have said, and I think I said it to this Committee, we have had for many years throughout the 8 Reagan years. I think, a well-defined science policy. We have support for defense, we have support for the basic research and support for the economy. Well, you could always find out how to support defense. I mean if you were interested in doing something on SDI you could listen to Abrahamson or listen to one of his project managers and go and talk to him, and if you're any good you're working on the project in very quick time.

In support of basic research, you would go to the NSF or the academies and read the frontiers in this or the frontiers in that, you know where the frontiers are.

In support for the economy, where do you go to find out how you support the economy?

So I think a better analysis of the Federal Government's investment in R&D and how it supports the economy would be a great thing, and that is one of the things that I would very much like to assist in and one of the things, or one of the areas that we are not working on at the moment in the Technology Administration. It's precisely that, namely, to carry the sort of work that I did with other people in the Department for Bud Brown further and analyze the underlying science, the underlying infrastructure in particular areas, what kind of scientific activity underlies this particular technology.

Mr. WALGREN. And do you see that responsibility as being focused in the Under Secretary of Commerce for Technology? Would that really be his or her focus responsibility?

Dr. AMBLER. I don't think it would really be focused there, because it has really got to be focused in OMB. So you need to get up one level higher. But I think the Under Secretary should have a very competent staff and have a lot of pipelines into industry for industry advice and have a big say-so in the review.

Mr. WALGREN. I guess what I'm fishing for is who in the system really must feel the personal responsibility for success in the endeavor of recommending what we do in emerging technologies? Take, for example, high-definition television and let's suppose there is something that the Federal Government should do, just take that as an assumption. Then let's suppose 10 years down the road the Japanese or the Europeans or somebody has just run away with the field.

What I want to know is who would feel terrible and who would be walking around with a sack cloth on saying gee, if I had only met my responsibility things would have worked out differently?

Dr. AMBLER. Well, you see, I was talking about type A technologies, the generic technology where you can take a longer-range view and you can look at generic technologies and you don't immediately get mixed up in all kinds of vested and special interests. I don't think you can do that analysis that I was speaking of in that way.

I think in the case of high-definition television the actions that the Department is taking and really the lead has been with the Secretary and Mr. Sikes, the head of NTIA, is they have a very high-level industrial committee made up of all the various interests, and we expect that they will be the people that will come with some suggestions. Now maybe there will be more than one. Maybe you cannot get complete consensus, and I suspect that might be the case, that you may have more than one, but you can't have too many, and then I think you have to come to grips.

For example, there was some discussion earlier about the standards question. Well, the standards question in high-definition television is really not the kinds of standards activity that NIST can be decisive about. I mean it can be involved, but that whole question is extremely complicated and very political.

For example, the first thing where there is pressure to come to some agreement internationally is in the, I forget what they call it, but it's the frame-rate of the picture. And this is not for broadcast

now, this is for production, and that affects the whole entertainment business, the whole movie business, it affects all the broadcast stations, and there is no way that that problem is going to be solved by somebody in the Under Secretary's Office or anywhere else dictating.

I read all kinds of studies, and a lot of them very good studies, but when they come to the recommendations, the recommendations are such that they demand a dictatorship, practically, to implement them, you see.

Mr. WALGREN. All right. I certainly appreciate that.

I apologize for going over my time. I would like to recognize the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

I would like to focus on the subject that has come up, and that is the cohesiveness of the policy, the locus of leadership in the Federal R&D economy. Do you see with the creation of the new Technology Administration within Commerce, do you see extrapolating from that a more cohesive leadership function in this Administration regarding the Federal R&D economy, the Federal R&D and RDT&E to use a defense term economy emerging?

Dr. AMBLER. I do see something along those lines. First of all, it's not with respect to R&D as such, but with respect to the cohesiveness among corporations, between government and industry and in some more national way that I believe is going to be required in order to take on the kind of competition that you see.

Mr. RITTER. But do you see this emerging in the new Bush Administration, this kind of response to the exigencies in the global competition, do you see an attempt to integrate the rather fragmented, diverse realms of R&D and technology development power within the Federal Government, the different interests that you talk about?

Dr. AMBLER. I don't think I see it at the moment, but then I don't think we have had long enough, really——

Mr. RITTER. I think that's right. I personally have been involved, and I sense that there is an interest in integration there, and whether or not that interest is expedited into policy given so many of the other pressures remains to be seen, but it seems that within this White House there is a real concern from Dr. Sununu on out—as to the fragmentation of this Federal R&D economy and the heretofore inability to generate a kind of team America approach to science and technology as opposed to a science and technology establishment driven by the political constituencies of the past agency policies. Do you sense that that's out there coming on?

Dr. AMBLER. Yes. I think you expressed it, in my opinion, extremely well.

Mr. RITTER. You mentioned that OMB is involved in a cross-cutting analysis.

Dr. AMBLER. Well, that's what Mr. Darman said in his confirmation hearing. I heard it on television, and I thought it was a great idea.

Mr. RITTER. The lingua franca, the common language of all this I guess is the budget. So it, of course, would have to be involved. But do you see that the Under Secretary of Technology might be part

of a larger team that perhaps the President's Science Adviser would be trying to put together?

Dr. AMBLER. Yes, I do. I have always thought that the Department of Commerce had to play a much stronger role, and of course the Under Secretary for Technology, that position would be enhanced.

Mr. RITTER. I have personally worked closely with White House personnel in this regard, and I sense that it's coming. I sense that a lot of important people have had to spend a lot of valuable time over the Towering inferno, but with that, hopefully, shortly out of the way, some of these issues will be much more effectively addressed.

Dr. AMBLER. I think you are absolutely right, and it's not only confined to those areas. I have started in the last two or three weeks to take some time to go and give talks to various groups. I've talked with the Council on Competitiveness, the IRI, IEEE, and so on, and there is no doubt that this sentiment is prevalent throughout the country. I think a course of action though is not yet clear.

On the basis of all of three or four months' experience of working in the Department of Commerce, I can say that I think that the help that the Department of Commerce gives business and industry in trade matters, intellectual property representation and so on, is very considerable, but it's all short range and not so much on the longer range. But I have the feeling that heretofore at least the Department of Commerce has done, on balance, just about what business and industry wanted it to do.

Mr. RITTER. One last question. Are we going to be able to provide a locus of federal interest and involvement in the subject of quality and in seeking to promote the quality revolution via the Malcolm Baldrige Award on the one hand, and via the potential cohesion of programs that have emerged on the federal level on the other?

Dr. AMBLER. Yes, I think we are. I think we can take a lot of satisfaction from the first year of the Malcolm Baldrige Award. It came off beyond my wildest expectations thanks to a handful of people and the cooperation with the private sector.

Mr. RITTER. I think on the one hand internally that's true. It is a crying shame, however, that the nation at large, the people, the culture has not been made more aware of the Malcolm Baldrige Award and all that the Baldrige Award means to jobs, standard of living and U.S. global competitiveness and what it means to corporations that have undertaken changes in corporate culture to achieve the Baldrige Award or to even apply for it.

I understand that recently Bob Galvin, the Chairman of Motorola has said that all suppliers to Motorola will have to either apply directly for the Baldrige Award or get ready to make an application, and they are not necessarily requiring this, but they are saying if you don't do this, you won't be a supplier of Motorola.

IBM and John Acres & Company have come to this conclusion, although not a Malcolm Baldrige Award winner, separately, and I just think we have to go about from the Secretary really and up to the President. We have to go about the Malcolm Baldrige Award at a far higher level of attention and sense of urgency because we do not have all the time in the world while the other side is going 90 miles an hour.

Dr. AMBLER. Yes, I think you're right. To the extent that we are not doing that, we will certainly give it attention because the legislation calls for us to do exactly what you're suggesting of course.

Mr. RITTER. That way you can take a real leadership role in it. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Ritter.

Dr. Caponio, as you mentioned in your testimony and recognized, the Japanese technical literature effort now resides specifically or organizationally I guess as part of NTIS or certainly reporting to NTIS. I just read in the paper greater and greater dimensions of Japan in terms of world power and economic power, and I wanted to underscore in some way the importance that I know many of us put on the efforts which we tried to point to through the Japanese Technical Literature Act.

One was establishing a presence in Japan, not just subscribing what the Japanese might produce in the way of technical information in English, but actually establishing and active presence there. Are we able to look forward to that?

Dr. CAPONIO. Mr. Chairman, I think Dr. Ambler probably would prefer to respond to that.

Dr. AMBLER. Yes. Well, the legislation certainly calls upon us to maintain an office in Japan as well as many other things, and we are looking into that possibility and trying to find out how much it would cost and how we could set that up. Of course, Dr. Caponio does have somebody in Japan already, at least an agent, not an employee of NTIS.

There are a number of things that we have to do under the Japanese Technical Literature Act, and it's a thing I have taken quite a bit of interest in since I have been Acting Under Secretary. Of course, this is a thing I was interested in several years ago. Of course, I think you came out to speak at the workshop out at NBS. It was then that this whole thing got kicked off. So I have had a deep interest in this for a very long time, and I have renewed my interest in working with Mr. Caponio and several other people to this end.

One of the things that strikes me as being a thing that I have to find out, and I have just set about doing this, and that is of all the things that Dr. Caponio makes available, all the other things that are available, some available from Japan in English and in various other private sector efforts, the take, a subscription is very, very low, and I worry about that. I think the first thing that I ought to do is to try to find out why that is so.

What I have done, one of the things, is I got permission from the other agencies in the Department to use their advisory committees. There are several advisory committees in the Trade Administration and Export Administration that go directly into industry, and I'm going to tell them what is available and ask them what's wrong. Have they no interest in this? Is it the wrong kind of information? And so on and so forth, because it may be that we could focus our efforts on certain types of literature and that would be much more useful. So that's one of the things I want to do.

Mr. WALGREN. Dr. Caponio, it struck me in your testimony that with respect to retaining the net revenues for modernization purposes the agency is still in the position of saying that they are re-

viewing the authority to do that to see whether it is legally sufficient I gather to carry out what was clearly the intent of the Congress.

Are there problems down that road for us? Last year we had all that pulling and hauling with the Administration wanting to privatize and us wanting to keep the functions in house governmentally and yet properly conducted. Does it take long to decide whether or not we have legal authority to do something?

Dr. CAPONIO. Mr. Chairman, in response to the first part of your question, I don't think it's pertinent to the issue of privatization any more. I think the reason why we are seeking a legal opinion is not so much regarding the funds that NTIS derives from the sale of its own information services and products. We feel that we can comply with the Congressional mandate and utilize those funds.

The question that requires clarification is the utilization of those revenues or receipts from brokerage services. By way of specific example, we are the major broker for the services of the National Library of Medicine, and it is in this connection that we are requiring a legal opinion, are we able to utilize the receipts or the revenues that are derived from the sale of the National Library of Medicine's information products.

Those revenues, as you know, Mr. Chairman, have always been returned to the Treasury and we are trying to obtain a legal opinion as to whether we can actually utilize these revenues or receipts which some feel belongs to the National Library of Medicine.

Mr. WALGREN. Is there any debate over the intent of Congress that you retain those?

Dr. CAPONIO. No, there is no debate whatsoever on that particular issue.

Mr. WALGREN. How about specific steps to implement Section 212 which, as I understand it, was the section which mandated the establishment and the maintenance of a permanent science and technical information repository?

Dr. CAPONIO. We are now complying with the requisites and the mandate of the legislation recently enacted, and we are maintaining the full archival responsibility. In addition, moreover, we are now embarked on a major project to modernize not only the internal operation, which we hope will reduce the costs of production, but also to increase the efficiency of dissemination especially by way of establishing joint ventures with the private sector.

So in response to your two-part question, we are modernizing the internal operations and we are also, modernizing the efficiency of the dissemination by working with the private sector.

Mr. WALGREN. Well, we wish you the best in that, and I know that Congress tried to grapple with that the last time and I hope we did it sufficiently.

Dr. CAPONIO. We are very much indebted to your Committee, Mr. Congressman, for assisting the NTIS with being able to move in the new direction of the electronic age of dissemination.

Mr. WALGREN. The Chair recognizes the gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman.

I apologize to our distinguished panel, but we are right in the midst of a hearing in Public Works and Transportation now trying to deal with the immediacy of the Eastern Airlines strike.

But I do have some thoughts that I would like to share with you, and others, and have in the record at this point.

The theme of these hearings can be boiled down to a single question: Whatever happened to competitiveness?

You remember competitiveness, don't you, the word that launched a thousand bills. It was all anyone could talk about last year. Congress, the Administration, economists, unions, industrialists all debated the issue passionately trying, and in many cases succeeding, to develop strategies to maintain and strengthen the nation's economic health.

But that was last year. Now our competitiveness problems have vanished. The Messianic Age has arrived, and our prosperity is guaranteed. Or at least that is the conclusion one would draw from the budget proposal before us this morning.

A scant 7 months after the signing of the Trade Bill, we find all of the competitiveness programs zeroed out, and the traditional NIST programs, which is an odd term for cutting edge research, still groaning under the crushing burden of absorbing pay increases, retirement changes and inflation. Perhaps I missed a news story about last year's legislation being vetoed.

I, for one, am not so willing to turn my back on last year's concerns, last year's agreements. These programs, the Hollings Centers, the Boehlert-Rockefeller Extension Service, the expansion of the Inventions Program, the Advanced Technology Program, were created with much care after thoughtful, if somewhat prolonged, discussion with the Administration. The problems that necessitated them are still a very real threat.

Mr. Chairman, speeches at NIST last fall, and you and I were there and we pledged that the name change at the Bureau was not just a superficial alteration. In December Secretary Verity announced the Hollings Centers with much fanfare, noting their potential contribution to our economic future, and the Boehlert-Rockefeller Extension Service, which at first was vigorously opposed by the Administration, was then embraced by the Administration, moving ahead even before the President put his name on the trade legislation.

When we were speaking at the NIST ceremony last year, and it was an exciting time for me, and I know it was for you, Mr. Chairman, I meant the words that I had to say, and I know you did also. I would suggest that we live by them.

Mr. Chairman, I look forward to working with you to restore these programs and to strengthen all of NIST. I only regret that our committee which prides itself on innovation, is forced, once again to engage in the same old battles.

I thank you, Mr. Chairman, and I apologize. My absence is not as a result of a lack of interest, but I'm vitally concerned about the future of our nation's transportation system. We have a jammed committee room over there, and shortly my questioning time will come and I will do my best to represent you and our interests.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you very much, Mr. Boehlert. I appreciate your coming.

Well, I'll tell you what let's do now. I would like to ask, Dr. Ambler, if you will stay with us, please, but we will replace Dr. Caponio with the group from NIST, and we will proceed with Mr. Kammer's testimony.

So we have been joined by Dr. John Lyons, the Director of the National Engineering Laboratory; Dr. Lyle Schwartz, Director of the Institute for Materials Science and Engineering; Dr. Harry Hertz, the Acting Director of the National Measurement Laboratory; Dr. Donald Johnson, the Acting Director of the Industrial Technology Services; and Lynn McNulty with the National Computer Systems Laboratory.

We appreciate your joining us, gentlemen, and let's proceed with Mr. Kammer's testimony.

**STATEMENT OF RAYMOND G. KAMMER, ACTING DIRECTOR, NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, ACCOMPANIED BY DR. JOHN W. LYONS, DIRECTOR, NATIONAL ENGINEERING LABORATORY; DR. LYLE SCHWARTZ, DIRECTOR, INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING; HARRY HERTZ, ACTING DIRECTOR, NATIONAL MEASUREMENT LABORATORY; DR. DONALD JOHNSON, ACTING DIRECTOR, INDUSTRIAL TECHNOLOGY SERVICES; AND LYNN McNULTY, ACTING DIRECTOR, NATIONAL COMPUTER SYSTEMS LABORATORY**

Mr. KAMMER. Thank you, sir.

This year the President is requesting $155.6 million for the National Institute of Standards and Technology. In a moment I will highlight each of the budget increases, but, first, I would like to report to you on some of the accomplishments and some of our progress in implementing the legislative mandates we have been given.

This past year has probably been one of the most eventful years in our history as we made the transition from the National Bureau of Standards to the National Institute of Standards and Technology. With the name change we saw the enhancement of our traditional measurement research and standards function to include a mandate to improve the competitiveness of U.S. industry.

This broadened mandate gives explicit endorsement to the strategies that we have been for some time pursuing through our cooperative research activities with the private sector. And we view cooperative research with the private sector to be a "way of life" at NIST.

I would like to illustrate this a bit with a brief review of the history and status of one of our largest recent projects, the Cold Neutron Research Facility. When it is completed in 1993, it will provide a vitally needed new national capability for measurement research on a variety of advanced materials.

To be established as a national user facility, we expect it to attract hundreds of private sector users every year, some of whom will be engaged in proprietary research. The architectural and engineering design contract for this unique facility was awarded less

than two years ago and the building was dedicated this last January.

We expect the four first experimental stations of about a total of 15 to be installed by the end of this year; and we expect that one-third of those stations will be equipped and used by the private sector. We have had considerable progress lately in getting commitments of funding. Exxon has contributed half a million dollars, Kodak $250,000 and the NSF, just last week, advised us that they were committing $996,000 for this year, and we expect that to be the first of a 3-year arrangement.

Congress has asked for a number of reports in recent legislation, including the development of an organizational plan for NIST. All of these reports are completed and they are in the process of review now. We hope that they will be available shortly.

On another topic. Following a review of 36 proposals by the National Research Council and by us, we made three awards to Regional Centers for the Transfer of Manufacturing Technology. These were announced in December of 1988 and they are, as I think the Committee knows, the Cleveland Area Manufacturing Program, Rensselaer Polytechnic Institute and the University of South Carolina.

Our 1989 appropriation legislation also mandated the establishment of a Center for Non-Destructive Evaluation and Manufacturing at Iowa State University and earmarked $7.5 million for the special project over the next three years. A Cooperative agreement establishing this Center was entered into in January.

The Computer Security Act of 1987 assigned to NIST the responsibility for dissemination of computer security techniques for Federal unclassified computer information systems. We have met all of our first-year assignments under this legislation.

To continue to fulfill the assignments, we will need an additional $3.5 million and 41 positions, and this will be to conduct research on security, architecture and standards for networks, methods, and also standards for securing database systems, and uniform personal identification and authentication methods.

We are currently conducting with NSA, the National Security Agency, a review of an estimated 1,500 security plans from all Federal agencies, as is required by the Computer Security Act.

In addition to that, we are in an ongoing discussion between us and NSA in an attempt to devise a memorandum of understanding. I am optimistic about this, and I believe that we will shortly be able to report to the Committee that NSA and NIST have implemented a procedure that is consistent with the legislation and is agreeable to both agencies.

The Committee may recall that—well, in fact I know we do because we were just talking about it—that about 18 months ago Commerce released a report that was prepared by Dr. Ambler on critical emerging technologies. We view these emerging technologies as those areas where scientific knowledge is well advanced, but for which the key to economic competitive benefits is their rapid commercial application.

At this point, a little over 40 percent of our directly funded research effort is devoted to the major emerging technologies identified in the Department of Commerce report. This didn't happen

suddenly, and it didn't happen in the last 18 months. It has actually happened over roughly the last eight years, and it has been a measured reaction on our part to our perception of the increasing economic significance of these technologies.

In order to respond to emerging technologies, we have to be very anticipatory, sometimes many years ahead of time, and we do this to a great extent by redirecting our own resources; sometimes in subtle ways and sometimes in rather direct ways.

Over the past several years we have been building up an effort in developing capabilities for finding, isolating and manipulating atoms and groups of atoms on surfaces and in free space. We have seen "atomic wires" that are only a few atoms thick. We have seen clusters of iron atoms that are probably no bigger than a single magnetic bit, and the embryonic formation of liquids and crystals formed from handful of atoms.

In my view, this is measurement science at the frontier. It's the kind of thing that NIST can do and do very well indeed and, more importantly, or as importantly, it is reasonable to expect that this will ultimately have a major impact in several emerging technologies, especially in driving electronics to its fundamental limits.

The President's 1990 budget request for NIST contains proposed increases for the most critical areas of research along with decreases reflecting overall fiscal constraints. The proposed increases for the Institute's budget include the following which, sir, in the interests of time I will list the ones that I know are familiar to the Committee due to prior consideration rather than discuss them.

The first one is process control and quality assurance, for which we are proposing an increase to $2.1 million.

Secondly, high performance composites, for which we are proposing a $1 million increase.

Third, lightwave measurement technology, for which we are proposing a $2.6 million increase.

High temperature superconductors, for which we are proposing $700,000 increase.

Bioprocess engineering, for which we are proposing a $2.3 million increase.

Computer security, which I alluded to earlier, for which we propose a $3.5 million increase.

And, finally, scientific computing, where we propose an upgrade for the current NIST computer at a cost of $3.1 million. This would be an upgrade both of our facility, which is also shared with NOAA, and the reason for proposing this increase is that the CYBER 205, which we acquired a few years ago, is now full.

In addition to program increases, we are proposing adjustments to base of a little over $800,000. We also have programmatic decreases that total $19.5 million. These include the industrial technology grants, and I would like to say a little more about that. We are proposing a $7.5 million reduction.

We have always played an important role in facilitating the transfer and effective use of technology. This particular program to finance the Manufacturing Technology Centers, however, is a new activity that represents a significant departure from the ongoing work of NIST as a laboratory based research facility.

In my view, the NIST initiatives to address emerging technologies as well as computer security and the scientific computer upgrade are of substantially higher priority than the expansion of the Manufacturing Technology Centers.

Another decrease of $7.5 million is for the Center for Integrated Design and Non-Destructive Evaluation in Manufacturing. This was a one-time appropriation and provides funding for this project for the next three years.

In fire and building safety research, we are proposing a reduction of $3.9 million. This would leave us with a $5 million program effort, and the fire program that we propose would directly address safety work, such as fire modeling and studies on the toxicity of combustion products. Similarly, in the building technology program we would focus on safety issues such as earthquake hazards, structural safety and engineering. The decreases in each program would be in the areas most directly related to efforts benefiting specific industries.

Since 1980, we have spent nearly $95 million on fire and building research programs, and we now propose that we allow the private sector to assume a larger part of this effort.

Other decreases include non-energy related inventions, for which we propose a reduction of $150,000, fire research on ignition of upholstery and general toxicity, for which we propose a decrease of $250,000 and the study of alternative refrigerants, for which we propose a reduction of $250,000. Each of these instances will have specific accomplishments in 1989.

The President's 1989 budget request for NIST included program increases that totaled $18.2 million needed to strengthen NIST base research programs in the areas of emerging technology and computer security. In the end, only $2.5 million of that was appropriated. Most of the rest of the $15.7 million difference was applied to grants that will be dispersed over the next several years, and indeed we are now coming back to Congress for these competitiveness initiatives.

I recommend against a policy of funding these grant programs in the NIST budget. NIST laboratory-based research programs have, in my view, a greater potential to enhance U.S. competitiveness through work on emerging technologies.

Moreover, there are many agencies that are already expert in managing grant programs. NIST is not yet one of them. There is no other laboratory in the United States, public or private, that is fulfilling the function of NIST. If NIST becomes a granting agency at the cost of its laboratory-based programs, the United States will have lost a unique and valuable resource, which is, in my view, essential to the future strength of our economy.

I would like to close with the report on a program which is having a major impact on the quality of U.S. goods and services, and that is the Malcolm Baldrige Quality Award.

The first awards, as this Committee knows, were presented by the President on November 14th of last year. They went to Motorola, Incorporated, to the Commercial Nuclear Fuels Division of the Westinghouse Electric Corporation, and to Globe Metallurgical, Incorporated. These three companies have exhibited outstanding leadership and initiative in sharing their successful strategies with

other companies and organizations. And of course the giving of the awards is a very important thing.

In my view, however, the single most important result of this unique, in my experience at least, industry and government cooperation is the development of the award examination itself. The document was developed with the work of hundreds of industrial individuals and quality experts. It's the basis for evaluating the applications, but it allows industry to do self-evaluation. Last year, we distributed 15,000 copies of this document. This year, we expect to distribute upon request 35,000 copies of this document.

Thank you for the opportunity to appear before you today, sir, and I would be glad to answer questions that you or any of the Committee Members have.

[The prepared statement of Mr. Kammer follows:]

U.S. DEPARTMENT OF COMMERCE
STATEMENT OF RAYMOND G. KAMMER, ACTING DIRECTOR
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
BEFORE THE SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
MARCH 7, 1989

Mr. Chairman, Mr. Boehlert and Members of the Committee;

I am pleased to appear before you today to request authorization of appropriations for the National Institute of Standards and Technology (NIST) for the fiscal year 1990.

Accompanying me is Dr. John Lyons, the Director of the National Engineering Laboratory; Mr. Jim Burrows, the Director of the National Computer Systems Laboratory; Dr. Harry Hertz, the Acting Director of the National Measurement Laboratory; Dr. Lyle Schwartz, the Director of the Institute for Materials Science and Engineering; and Dr. Donald ohnson, who will manage the programs which were funded for FY 1989 for our Trade Act assignments.

This year the President is requesting $155.6 million for the National Institute of Standards and Technology. Measurement is vital to all segments of the United States' industrial economy to assure quality and cost competitiveness of high-technology products and services. This request recognizes NIST's valuable and unique role in providing measurement-

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related scientific and engineering research and services to support U.S. industry, government, and science. In recognition of the Nation's increased dependence on technology-based trade, NIST has focused many of its proposed initiatives on the emerging technologies and on process and quality assurance techniques needed by U.S. industry to accelerate the commercialization of new high-technology products and services.

We are asking for increases for measurement research in critical emerging technology areas of chemical process control and quality assurance, lightwave measurement technology, high performance composites, high-temperature superconductors, and bioprocess engineering. Increases are also being requested for computer security and for an upgrade to our scientific computer.

Our request is responsive to the recommendation contained in the most recent report of John Young's Council on Competitiveness that the Congress "increase funding for government programs that have high leverage in enhancing the commercial application of technology." The Council's report specifically recommended that "systematic increases should be sought for the National Institute of Standards and Technology (NIST), which is the primary Federal laboratory with an explicit mission to aid U.S. industry."

Each of the budget initiatives will be discussed in detail later in this statement. First, I would like to report to you on some of our accomplishments and on implementation of some of the legislative mandates that we have been given.

This past year has probably been one of the more eventful in our history as we made the transition from the National Bureau of Standards to the National Institute of Standards and Technology. With that name change, we saw the enhancement of our traditional measurement research and standards function to include a mandate to improve the competitiveness of U.S. industry by providing expanded infrastructure support in generic technology research and quality assurance. This broadened mandate gives explicit endorsement to the strategies that we have long been pursuing through our cooperative research activities with the private sector. Cooperative research with the private sector continues to be a "way of life" at NIST.

I would like to illustrate with a brief review of the history and status -- a real success story -- of one of our largest recent projects. The NIST Cold Neutron Research Facility (CNRF) adjacent to our Research Reactor at the Gaithersburg site, when fully completed in 1993, will provide a vitally needed new national capability for measurement research on a

variety of advanced materials (e.g., ceramics, polymers, proteins, and superconducting and magnetic materials). To be established as a national user facility, we expect it to attract perhaps hundreds of private-sector users every year, some of whom will be engaged in proprietary research. The architectural and engineering design contract for this unique facility was awarded less than two years ago. The building was dedicated Jan. 12, 1989 by Secretary Verity, and we expect the first four experimental stations (of a final total of 15) to be installed by the end of this year. It is important to note that one-third of the stations will be equipped and used by the private sector. To date, Exxon has contributed $500 thousand, Kodak $250 thousand, and the NSF $996 thousand for FY 1989. The NSF contribution is for the first year of a three-year agreement.

Congress has asked for a number of reports, including the development of an organizational plan for NIST. I am pleased to report that all of the reports are completed and will be available shortly. A new organizational plan for NIST was prepared after consultation with the Visiting Committee on Advanced Technology and is also currently under review.

Following a review of 36 proposals by the National Research Council and NIST, awards for three regional Centers for the

Transfer of Manufacturing Technology were announced in December 1988 to the Cleveland Area Manufacturing Program, the Rensselaer Polytechnic Institute, and the University of South Carolina. Unlike these awards, which were the culmination of a competitive review process, our 1989 appropriation legislation also mandated the establishment of a Center for Non-Destructive Evaluation and Manufacturing at Iowa State University and earmarked $7.5 million for this special project over three years. A cooperative agreement establishing this Center was entered into in January 1989.

The Computer Security Act of 1987 (P.L. 100-235) assigned NIST the responsibility for dissemination of computer security techniques for Federal unclassified computer information systems. The recent computer virus attack on a national computer network underscores the importance of NIST's role in promoting cost-effective computer security. NIST has been requested by the Secretary of Defense to help support unclassified computer systems by setting up mechanisms to exchange information on computer attacks, a task which supplements NIST's legislated role in computer security. NIST has met all of its first year assignments under the Computer Security Act. To continue to fulfill its assignments NIST needs an additional $3.5 million to provide 41 positions to conduct planned research on security architecture and standards for networks, methods, and

standards for securing database systems, and uniform personal identification and authentication methods. These standards, guidelines, and methods will help assure that data is processed correctly and is available when needed and that only those authorized to use it have access. We are currently conducting, jointly with the National Security Agency (NSA), a review of an estimated 1,500 security plans.

There is an ongoing discussion about the respective roles of NIST and NSA on computer and network security. NIST has been conducting discussions with NSA to develop a formal memorandum of understanding that will define responsibilities of both organizations. I believe we will shortly be able to report to the Committee that NSA and NIST have implemented a procedure that is consistent with the legislation and is agreeable to both agencies.

The issue of whether to increase user fees for NIST measurement services has been a source of much discussion over the past two years. We recently received consent from the House Committee on Science, Space and Technology to increase fees charged for Standard Reference Materials and Calibration Services. These fees will be used to offset costs associated with developing new and/or improved Standard Reference Materials and Calibration Services and should allow NIST to be more responsive to the needs of industry and

science where new or updated materials and measurements are wanted. The Committee asked that NIST, in implementing this increase, be sensitive to the impact of pricing of its calibrations and materials on organizations with limited resources. We intend to give very careful consideration to these concerns.

Mr. Chairman, you may recall a DOC report released 18 months ago that provided a status and futures assessment of seven of the most critical emerging technologies. Emerging technologies are those in which scientific knowledge is already well advanced, but for which the key to economic competitive benefits is their rapid commercial application. These technologies will have an even greater impact on our economic well-being over the next several decades than they have in the past. About 40-45% of our directly funded research effort is devoted to the major emerging technologies identified in that DOC report. This didn't happen suddenly, of course; it has been a measured reaction to the increasing economic significance of these technologies.

In order to provide the measurement foundation needed to accelerate the development and use of science and technology by industry, NIST must continue to <u>anticipate</u> technical innovation. The only way to keep pace with the increasing sophistication and pervasiveness of technology is through

selected program revisions and expansions that reflect key growth areas of the economy. This we can do, to some extent, by redirecting our own resources and using resources provided by other agencies.

We have, for example, been nurturing within the Institute a half-dozen small programs that are developing capabilities for finding, isolating, and manipulating individual atoms and groups of atoms on surfaces and in free space. We have seen "atomic wires" only a few atoms thick (a single human hair is a million atoms thick), a cluster of iron atoms that is perhaps no bigger than a single magnetic bit, and embryonic liquids and crystals formed from a handful of atoms. This is measurement science at the frontier -- what NIST scientists do best -- research that could ultimately have a major impact on several emerging technologies, including electronics and thin-layer technology.

NIST budget initiatives are, of course, the primary vehicle for program expansion. The President's FY 1990 budget request for NIST contains proposed increases for the most critical areas of research, along with decreases reflecting overall fiscal constraints. Proposed increases to the Institute's FY 1989 budget include:

- Process Control and Quality Assurance (16 positions and $2.1 million): Chemical measurement technology, standards, and reliable data are crucial to enhance productivity, introduce new technologies, and meet the competitive challenge in a range of international markets. For many emerging technologies, no chemical measurement base exists. This request would allow NIST to advance the chemical measurement science needed for new high technology industries and to improve the quality assurance of chemical measurements.

- High Performance Composites (10 positions and $1.0 million): Composites are attractive because of their high strength and stiffness, corrosion resistance, design and manufacturing flexibility, and effectiveness in conserving critical materials. They are an important area of world-wide competition in which the United States is no longer a clear leader. The program at NIST would focus on developing basic information needed to link the microstructure of material components to their performance characteristics.

- Lightwave Measurement Technology (Fiber Optics) (30 positions and $2.6 million): Lightwave technology is the basis for current and future communications and computer systems. Competition is intense in the international

market for fiber optic components -- currently $2.5 billion per year and expected to reach $11 billion by the year 2000. This increase would add to the $2 million base program and enable NIST to provide the measurement capability that U.S. industry needs to develop and sell more competitive opto-electronic components in the world market.

- High Temperature Superconductors (8 positions and $700 thousand): International competition to develop and market superconductor products is unprecedented. This increase would enhance NIST's ability to conduct a research program as specified in the President's Superconductivity Initiative. The initiative called for NIST to develop measurement methods, standard reference materials, and supporting data as well as devices for measuring weak magnetic fields. In addition, it called for the establishment of a center of excellence at NIST for electronic applications. NIST has already made many contributions including implementing the first superconducting electronic device capable of operating at liquid nitrogen temperatures and fully characterized as a measurement device.

- Bioprocess Engineering (29 positions and $2.3 million): The United States currently leads the world in fundamental

biochemical research and innovation in the laboratory, but is behind in the world competition to get the technology to the marketplace. The NIST program would focus on providing U.S. industry with the foundation of physical and chemical measurements needed to facilitate manufacture of products from microorganisms and animal and plant cells in commercial quantities at low cost. In particular, areas of proposed research include monitoring and control of bioreactors, commercial separation and purification of bioproducts, measuring thermophysical properties needed for design, and identifying and characterizing the relationship between molecular structure and conformation and chemical process behavior of biomolecules.

- Computer Security (41 positions and $3.5 million): The Computer Security Act of 1987 (P.L. 100-235) gives NIST the primary responsibility for developing standards and guidelines needed to secure sensitive, unclassified information in Federal computer systems.

- Scientific Computing Upgrade (no positions and $3.1 million): These funds have been requested to upgrade the scientific computing facility used by both NIST and the National Oceanic and Atmospheric Administration, another Department of Commerce agency. The scientific staff of

both NIST and ERL need more powerful, flexible and useful computational tools to improve scientific productivity.

In addition to programmatic increases, adjustments to base budget of $809 thousand are requested. This amount includes an increase of $848 thousand for 1989 pay increases and related costs; $949 thousand for personnel benefit cost increases; and $795 thousand for inflationary increases in the costs of goods and services. It also reflects a decrease of $475 thousand resulting from anticipated management savings through A-76 studies and a transfer of $120 thousand to the Office of Space Commerce. An addition, Congress appropriated, on a one-time basis, $1,189 thousand in FY 1989. We are decreasing the budget by this amount in FY 1990.

Proposed programmatic decreases total 64 positions and $19.5 million. They are:

o Industrial Technology Grants (-8 positions and -$7.5 million): The FY 1989 appropriation for this program provided $7.5 million which is sufficient for a several year program operation. NIST has always played an important role in facilitating the transfer and effective use of technology. The program to finance the Manufacturing Technology Centers, however, has introduced

a large, new activity to NIST that is a significant departure from its ongoing work as a laboratory-based research facility. In my view, the NIST initiatives to address emerging technologies, computer security, and a scientific computing upgrade are of substantially higher priority than the expansion of the manufacturing technology centers program.

- Center for Integrated Design, Non-Destructive Evaluation and Manufacturing (no positions and -$7.5 million): As mentioned earlier, the one-time FY 1989 appropriation will support the Iowa State University Center for a three-year period.

- Fire and Building Safety Research (-49 positions and -$3.9 million): This would result in a $5 million program effort. The fire program that we propose would directly address safety work such as fire modeling and studies on the toxicity of combustion products. Similarly, the building technology program would focus on safety issues such as earthquake hazards, structural safety and engineering. The decreases in each program would be in the areas most directly related to efforts benefiting specific industries. Since 1980 we have spent nearly $95 million on the fire and building research programs. It

now is appropriate for the private sector to assume more of this effort.

Other decreases include non-energy related inventions (-1 position and -$150 thousand), fire research on ignition of upholstery and general toxicity studies (-3 positions and -$250 thousand) and study of alternative refrigerants (-3 positions and -$250 thousand). In each of these instances, specific accomplishments will be achieved in FY 1989.

The President's FY 1989 request for NIST included program increases totaling $18.2 million needed to strengthen NIST base research programs in areas of emerging technologies and computer security. In the end, only $2.5 million of that was appropriated. Virtually all of the $15.7 million difference was applied to grants that will be disbursed over several years. Therefore, we are coming back to Congress for these competitiveness initiatives.

I recommend against a policy of funding these grant programs in the NIST budget. NIST laboratory-based research programs have a great potential to enhance U.S. competitiveness through work on emerging technologies. There are many agencies already expert in managing grant programs -- NIST is not one of them. There is no other laboratory in the United States, public or private, fulfilling the function of NIST.

If NIST becomes a granting agency at the cost of its laboratory-based programs, the United States will have lost a unique and valuable resource which is essential to the future strength of our economy.

I would like to close with a report on a program which is having a major impact on the quality of U.S. goods and services -- the Malcolm Baldrige National Quality Award. The Secretary of Commerce and NIST were given responsibilities for implementing the Malcolm Baldrige National Quality Improvement Act of 1987 (Public Law 100-107) which created an annual Quality Award for the U.S. The purposes of the Award are threefold: (1) to promote quality awareness; (2) to recognize quality achievements of U.S. business; and (3) to publicize successful quality strategies.

Working with private sector business leaders, quality experts, and trade and professional organizations, NIST has established a system for examining Award applications and providing feedback to all applicants on their quality systems. A network of publications and individuals has been established to publicize the Award and the findings of the Award.

The first Awards were presented by the President on November 14, 1988. They went to Motorola, Inc., the Commercial

Nuclear Fuels Division of Westinghouse Electric Corporation, and Globe Metallurgical, Inc. These three companies have exhibited outstanding leadership and initiative in sharing their successful strategies with other companies and organizations.

The single most important result of this unique industry-government cooperation is the development of the Award examination. Input to the document has come from hundreds of industries and quality experts. It is the basis for evaluating applicants but more importantly it is a simple, effective communication tool for promoting a common awareness of quality at the national level. The 44 items described in the examination bridge quality principles and practice and . they integrate manufacturing and service quality requirements within a single framework. Businesses are using the examination for self assessment, for initiating quality systems, for communications and comparisons, and as an adjunct to education and training particularly at the management level. Twenty thousand copies have been distributed since January. We expect to distribute another fifteen thousand in the next few months.

Thank you for the opportunity to appear before you today, Mr. Chairman. I shall be glad to answer any questions you, Mr. Boehlert or the other subcommittee members may have.

Mr. WALGREN. Thank you very much, Mr. Kammer. We appreciate that.

Do other folks have statements they would like to make, or are we all in order?

Mr. KAMMER. We are all set, sir.

Mr. WALGREN. Let me take you, Mr. Kammer, to page 14 of your testimony in which you are sort of summarizing the rise and then the waning of President Reagan's FY-89 request where the Administration proposed program increases totaling $18 million for base research programs and emerging technologies and in the end only $2.5 million of that was appropriated, but then the balance of the $15.7 million difference was applied to grants that will be dispersed over several years.

Tell me how all that comes together. I guess I don't quite understand what happened there.

Mr. KAMMER. Well, the authorization process did afford the possibility of funding the emerging technologies, and I think it also contemplated making some progress on the new assignments as well.

The appropriations process in the House provided no new funds. It held to the prior level of 1988, fiscal year '88 of about $145 million approximately.

The Senate appropriations process planned funding of about $151.5 million, if memory serves, and in that process there was some money for the emerging technologies and there was some money for some of the Trade Act responsibilities.

During the conference between the House and Senate Appropriations Committees, the dollar number was raised to $159 million, and the amount of money planned for the Regional Manufacturing Centers was raised from a level of I believe $3.5 million in the Senate to a level of $7.5 million, and the concept of a Non-Destructive Evaluation Center for Design and Manufacturing purposes was introduced at this point, and that was also funded at $7.5 million. It's those two $7.5 million numbers that yield the roughly $15 million that is discussed in that paragraph.

Mr. WALGREN. And that was applied to these two grant programs?

Mr. KAMMER. Yes, sir.

Mr. WALGREN. And your conclusion is that that was taken away from the Administration's request in emerging technologies and base support; is that right?

Mr. KAMMER. It's never I guess totally appropriate to prejudge the decisions of Congress. There seemed to be an intent and a plan to fund a substantial part of the emerging technologies before the appropriations conference and after that there wasn't. The initial proposal in the President's budget was of course to fund those programs up to about $159 million, which would have been an increase of roughly $15 million.

Mr. WALGREN. Well, of course a lot of our problem comes in the interaction between Authorization and Appropriating Committees and it is not an orderly fit. You are coming back and saying that you recommend against a policy of funding these grant programs in NIST's budget, and I guess I would like to question that a little bit.

It would seem that one approach to authorizing a budget would be to give the authority for what should happen to happen. Now whether it can happen or not is really somewhat beyond our control and may be more in the Budget Committee's control or ultimately of course in the Appropriations Committee's control, but I would feel badly if we did not authorize what we would want to do to give it at least the power to happen if it can happen. And under that approach to authorization would you still be opposed to authorizing these grant programs?

Mr. KAMMER. I think there are sort of two different questions. One is a question of priority, and I take it you're asking the second question, which is do I regard it as appropriate to have a grant program as is envisioned by the Trade Act in the NIST budget.

I was, and I remain, very intimidated by the circumstances of last year's decisionmaking process by Congress, and I was very struck then and remain so by the kind of tradeoffs that can be made between grant programs and laboratory based programs.

It may be, and this is a question to which I don't have the answer, and I don't think I'm the appropriate judge, I leave that to my betters, but it may be that it is not possible to have a decisionmaking process that makes head-to-head tradeoffs between grant programs and laboratory programs.

Conceivably the grant programs have a character to them in terms of their immediacy of topic that responds to what appears to be a very urgent problem today that simply makes it very hard for a longer-term effort. The strategy that we embark on in these emerging technologies even is typically a 3-, 5- or 7-year effort, and you will give very little satisfying result the first year when people are being asked to make decisions between a grant, which does have an immediate instrument and there is an event where someone receives the grant and something happens, versus a research program where we are going to go away and we are not going to give you a result for quite a while. I'm not sure whether they can dwell together, and I raise that as a question and not an answer.

Mr. WALGREN. Setting aside these particular grants, which I suppose people can argue about, the process of grant making, for example, through the National Science Foundation, is a very effective way of getting the best talent focused on specific problems, and it would seem to me to be a very efficient way, and it would be disappointing I think to think of the NIST as taking a position that that's something that they don't want to get into because they just want to be this laboratory where all the work will be done by people who have a personnel relationship with the laboratory with all difficulties that that entails from the Federal Governmental standpoint.

It would seem to me that it would be very important to take advantage of opportunities of doing things on the outside to grant arrangements.

Mr. KAMMER. Sir, I'm certainly not suggesting that. As you say, NSF has been remarkably successful. DARPA we were talking about earlier, and there are some activities where it's the only potential you have for rapid response, and DARPA is a very good example of that, but NSF has also been from time to time.

Mr. WALGREN. But even the potential to get somebody working on a project you would not otherwise be able to get because they are not physically able to come and move to Washington or become a federally assigned person.

Mr. KAMMER. Or I can't afford them.

Mr. WALGREN. For example, a fire program has been done through the University of Pittsburgh and has been able to tap in very efficiently to four hours of a very good person's time per day or something like that. I mean the abilities to take advantage of our system are so great that I would really want you to not be turning away from that in any way.

Mr. KAMMER. The fire program to which you alluded has been a very positive experience for us, and I think we have gotten some things done that we couldn't have gotten done any other way.

The recent events in the other two examples have been I think less advantageous to the Bureau, and I did argue for a different decision.

Mr. WALGREN. Fine. I think that is proper within that context. I am wondering what our role as an Authorizing Committee is because there were benefits in those grants as well. One of the things that is going on I think across the government is it's sort of like an alcoholic, we're sort of hitting rock bottom is what we are doing, and when you hit rock bottom bad things happen. And just as in counseling alcoholics, apparently there has to be a realization process that goes on, and one of the realization processes is that given our system, monies which you would have rather seen disposed of in a basic research sense where it was really needed were not available because with public decision-making it was drawn to another use.

Now we can argue about whether or not it should be drawn to another use, but the fact that it was is indication that that might be the real world, and then the real world confronts us with underfunding the basic function, and we are, like an alcoholic, hurting because we have hit the bottom in that particular area.

Well, we'll have more opportunity to discuss it.

The Chair would like to recognize the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

We talk about the difference between grant programs and then the programs out in the lab itself. One of those grant programs, and I think we all have to admit it, was not budgeted and was not authorized by this Subcommittee and full Committee. It was thrown in as is wanted to do in recent years at the 11th hour in the Appropriations Committee, and that's nearly half of the entire grant program allocation, and none of us ever even knew that this thing was happening.

I think that is not the kind of responsibility that needs to be exerted by us in Congress regarding the NBS or any other agency, but nevertheless that happened, and I really sympathize with you and the Bureau and NIST on that particular situation, and I hope that we don't allow that to happen again. We have a responsibility, and that kind of action goes outside the fulfillment of the responsibility of this Authorizing Subcommittee.

But getting back to the rest of that more or less $50 million, the grant program of the manufacturing centers, and maybe you want to call on Dr. Johnson on this, but what do you see as the problems with a grant program like this for manufacturing, and related to that, what is our status in the NIST in advanced manufacturing, and are we getting the kind of resources into advanced manufacturing that America's global competitive needs cry out for?

Dr. JOHNSON. Well, I think as far as the three centers that we have established this year, they are, as you are well aware, designated now. We have made transfer of funds through the Camp Center in Cleveland. Cooperative agreements have been consummated with Rensselaer University and with the University of South Carolina. In all three cases the initial agreements are for a transfer of $1.5 million each. There are additional funds available from a combination of your appropriations last year and the year before that will provide additional funding for each of those three centers. As we finalize further negotiations with them, you will remember——

Mr. RITTER. Are you referring to the additional $7.5 million?

Dr. JOHNSON. Yes. You might remember that the total appropriation that we had available this year was $7.5 million new money, and we had some money from FY-88 that was not expended, $4.5 million that was carried over. So from a combination of those funds, both this year and carryover from last year, we have more than $1.5 million available——

Mr. RITTER. Is the essence of those centers, Dr. Johnson, to transfer NIST developed advanced manufacturing technology into the field? I know it has kind of changed as the proposal process was evolved. What eventually was the essence of those field manufacturing centers?

Dr. JOHNSON. The primary focus of all three of the centers that we have established this year is to transfer commercially available technology to small manufacturing firms to the maximum extent possible.

Mr. RITTER. OK, and not necessarily NIST——

Dr. JOHNSON. Not necessarily NIST developed technology, but our ultimate goal is to bring the level of technical expertise within those small firms to the point where they can accommodate technology at the state of the art. We would very much like all small manufacturing firms in the service areas of those three centers to be able to accommodate technology at the state of the art. It's going to take a while to get there, Mr. Ritter, and we will start by trying to focus on the largest number or the largest fraction of the population of firms in those service areas in trying to move them towards improved technology capability.

Mr. RITTER. So the $7.5 million is going to go to those existing three centers; is that the strategy now?

Dr. JOHNSON. Yes, it will go to the existing three centers. A portion of the funds, about 10 percent of the funds will be used at NIST, a major fraction of that in the general area of our automated manufacturing facility to pay for staff support there and pay for the costs that are associated with bringing technical people from the centers to get them exposure to our technology and to pay for our own staff time.

Mr. RITTER. What is the status of your own laboratory, your own technology? What is its status? Is it at the cutting edge any more, it is kind of starting to fall behind, it is in need of——

Dr. JOHNSON. Well, I can certainly give you my opinion. I have been traveling a lot in the last year, and it certainly appears to be at the cutting edge. I think Dr. Lyons is probably better prepared to answer that question, Mr. Ritter, since he is really the line manager responsible for the AMRF.

Mr. RITTER. Is AMRF getting its cutting edge out into these three individual centers? Is that part of the plan as well?

Dr. LYONS. Yes, sir. Our program in manufacturing engineering, which includes the AMRF, has really been the focus point I think for Congress as well as for most of the people in the private sector. I think it's at the state of the art. It's the largest team program at NIST by a long shot. We have something like 150 staff members associated with it. You may recall that that's the program that has had research associates from industry to the extent of about 70. We have got three dozen universities involved, and the technology keeps rolling forward.

The AMRF, as it was completed a couple of years ago, represented a particular state of the art at that time. We continue to move ahead largely in software development and smart machine technology beyond what we have in the current——

Mr. RITTER. And the mechanism to get that out into the field is through people coming in and working with it and then the people transfer the technology when they go back; is that it?

Dr. LYONS. That certainly is the most effective way, and that is why I stress those research associates that come to us from industry and spend say up to a year with us.

Mr. RITTER. How many research associates?

Dr. LYONS. Seventy, of that order. Some of them come for a year, some of them come part time and come in and out to pick up technology. We have found, Mr. Ritter, that it is fairly straightforward to transfer that technology to big firms. So Boeing Commercial Aircraft comes in and they know how to extract that technology from us. They are very efficient. That's one example.

Medium-sized firms are a little harder to deal with. They don't have research staffs, but typically they have an engineering staff. It's the thousands of small companies that we're struggling with, and that's why the people in my program welcome these manufacturing technology centers because that works from the States and gives us a kind of a cascading down effect. We have high hopes that that's one way to reach small companies that we can't do directly.

Mr. RITTER. Let me ask just one closing question. The revolution in management via quality and the whole idea of the Baldrige Award to promote the acceleration of quality processes in the field across the country, that being the case, is there any effort to kind of combine the transfer of quality management, of quality processes and quality education out into the field to accompany the technology, and, particularly, in the work that you do with manufacturing centers, the three that you mentioned and others around the country?

I am really concerned that the technology without the process is going to put us behind in the same way that General Motors fell behind Ford when they had all the dollars and all the technology in the world and Ford had some technology but lots of process.

Is there any discussion within Commerce and NIST to link closely the transfer of technology with the transfer of some of the management changes that we have seen and management processes that we have seen that so impact on the manufacturing process?

Dr. JOHNSON. Mr. Ritter, the short answer to that is yes. There certainly have been in many different quarters. Let me address the manufacturing technology centers that we were speaking of just a few moments ago specifically.

There it's very clear that small companies that are vendors to large companies are beginning to feel the pressure of the quality movement reflecting back onto them. Big companies have been very quality sensitive now for the last several years, and many large companies that are heavily involved with vendor suppliers like General Motors have very extensive quality programs that even offer audit services to smaller firms.

We think that a primary driving force that will cause a small business, a small manufacturing firm to cooperate with our center and seek to improve their technical position is going to be the quality movement in big companies that they supply. We see the real driving force not being economics as much as quality, and our guess is, and at this stage it's just a guess because none of these centers are really up and operational in a full sense of the word yet, but our guess is that quality is going to be a very major factor in the involvement of small firms with the centers as we develop them.

Mr. KAMMER. Sir, if I may give you a slightly more general answer as well. In the rewrite of our Organic Act, in addition to the Baldrige Award, the concept of quality was introduced into the general motivating and assigning language as part of our mission as well.

Mr. RITTER. We did it right here in this Committee.

Mr. KAMMER. Exactly. We think the key to this is statistical quality control, if you will, in the manufacturing process, and I think process is the right word just as you were using earlier. We have begun to think about this, and in fact we now employ an expert in that discipline, something we did not do until about eight months ago.

I have asked Curt Reiman, who is also the manager of our Baldrige Award activity, to also take this on as an assignment because that is where the visibility is and that is where the attention is. And one of the mechanisms for distributing this of course is the incorporation in the criteria and the like.

In looking over our own programs, we have found that there are a number of examples of calibration services and test method concepts that we have either helped develop or have developed ourselves that do incorporate these concepts, and this has just grown up from the laboratory level rather than down from the management level in all honesty. We are looking at a couple of those to use them as sort of school cases, if you will, of what's going on. I

believe that all of our services to industry ultimately need to incorporate the kinds of concepts that we're talking about.

Mr. RITTER. I guess that's the point I'm trying to make. I think it's absolutely essential to understand that the technology alone is not going to do it. I would advocate for your programmatic approach to manufacturers and manufacturing and your industrial liaisons where appropriate to try to integrate the concepts behind the Baldrige Award and maybe even get involved in more programmatic assistance. There are two percent of the American companies that are involved in significant quality approaches and nearly 100 percent of our competition is involved in it.

I heard a comment by the Premier of China yesterday afternoon that China has trained, actively trained, and this is using Japanese techniques and borrowed from America, 4.6 million people working in companies involving 16 million people, and the Premier of China thinks that this is going to really have a tremendous impact on global competitiveness for China, and I was surprised. But I urge you to really try to move forward in that area, and it really would support the Baldrige Award and promote the Baldrige Award.

Dr. AMBLER. I might add just one thing. We have had a very good connection with the Under Secretary of Defense for Acquisition, Bob Costello. That was established before I came with Bob Rushmer and his people in this particular area, and I know that their interest is in this total quality picture and they understand it the way we understand it. So that's another leverage point.

One of the things that I'm trying to work out with Mr. Kammer is to see whether we can't have somebody work in that office so that the experience of the Baldrige Award and that kind of activity can be used and we can get some assistance in what they are trying to do in the Defense Department.

Mr. RITTER. Thank you, Mr. Chairman.

Mr. WALGREN. The gentleman from Colorado, Mr. Skaggs.

Mr. SKAGGS. Thank you very much, Mr. Chairman.

Gentlemen, I'm sorry I wasn't here to hear your presentations. We are in the throes of the Eastern Airline issue over in another Committee that I sit on, but I appreciate the opportunity to come in late.

A few questions as someone who represents an area that includes one of your major facilities. I need some linguistics training still to train my brain to get away from NBS and onto NIST, but in any event, one of the significant events, unfortunately, for the Boulder facility was the fire last year. Would you fill me in on what you have done as far as requests for supplemental or emergency funding to deal with the fire in the superconductivity lab in Boulder?

Mr. KAMMER. Surely, sir. The first of course occurred on December 27th, 1988. I'm not sure why it is always this way, but it was our largest clean room on the site and it was our most extensively equipped clean room as well. Fifteen of our leading scientists and engineers require the use of this facility to do their work. So this is a pressing problem for us.

To that end I have already instructed our people to go ahead and start the repair process. If we are able to persuade the budgetary system that a supplemental is appropriate, then well and good, but even so we have to fix the facility. We can't leave it that way. We

are presently working off of the $2 million that we were directed to take from carryover and spend it on superconductivity, and with that money we have let a contract already to take the wreckage apart, if you will, and to scrub the space down. It has to go right down to the bare walls and start all over again.

We have also let a second contract for the initial work to start renovating the facility that represents the walls and the utility services that come in and the like. That should be accomplished by June of this year. It will have been completed, and at that point we can begin operation on a limited basis and begin to move some equipment back in.

What decisions will be made with respect to the budget process and the possibility of supplementals, I don't know at this point.

Mr. SKAGGS. But how much money do you estimate now it's going to take to repair the damage and re-equip the room?

Mr. KAMMER. What I have available is $2 million at the moment, and it will take certainly that amount to do it.

Mr. SKAGGS. What is your estimate of the total?

Mr. KAMMER. Well, I'm in a position where I'm in a negotiation with my various bosses about the budget, and I don't think I'm supposed to talk about budget numbers until I'm told what the answer is. I think that's as far as I can go, sir.

Mr. SKAGGS. You mean there is no estimate that you can provide this Committee as to what it is going to cost to repair that facility?

Mr. KAMMER. I have provided an estimate which I hope my various bosses in the Department will find persuasive.

Mr. SKAGGS. I'm not asking you what you think you're going to spend this fiscal year, but what you think it's going to take to get the job done eventually.

Mr. KAMMER. My feeling is that I may have a negative effect on the likelihood of persuading people to support the supplemental by pressing it too vigorously in a public forum just now.

Mr. SKAGGS. Okay. I take it there has been no action at the Departmental level as far as forwarding your request?

Mr. KAMMER. They are currently reviewing it at the Department.

Mr. SKAGGS. What is the time line on Departmental action on that?

Dr. Ambler, do you have any insight into that?

Mr. KAMMER. Dr. Ambler has approved it. The likelihood is that they would reach a conclusion in the next couple of weeks, say the next two.

Mr. SKAGGS. So I could reasonable ask you to advise me of the status of that by the end of March?

Mr. KAMMER. I take it you just have, sir. [Laughter.]

Mr. SKAGGS. I don't want to ask you questions that you can't respond to.

Mr. KAMMER. And we will advise you.

Mr. SKAGGS. Great. There is no insurance to cover this loss obviously. In my explorations of this problem, we have received the response that this is essentially self-insurance, which is an interesting notion in the context of a government laboratory I think.

What does that concept of self-insurance really mean in these circumstances? Who pays the freight when we have a loss?

Mr. KAMMER. There is really only one source of money, and it's the government. The general concept when there is a disaster is that there is then an effort by the Program Manager, whoever it is, even taking it past our case, to persuade the central disbursing agent, the budget offices that this is something that can't be accommodated within current money and can you take more money out of the Treasury and provide it to us.

In sum, what self-insurance means is that there really isn't any money set aside for this kind of thing, and you start from there.

Mr. SKAGGS. And compared to self-insurance as it's used in the private sector in which generally accepted accounting principles would require some reserve for losses, this is totally alien.

Mr. KAMMER. There is no such thing in the government.

Mr. SKAGGS. Now this is dear to my heart obviously because it affects the people I represent, but in trying to get less parochial about it, it certainly also affects an area of research that we as the Congress and I think with the endorsement of the Administration have identified as critical to our efforts to be competitive in the superconductivity area.

Given that, let me just make the observation that I would hope that the Department would use its strongest arguments and best offices with the folks at OMB to get you want you need to get this job done promptly.

Let me also make the request that at such time as you are able to provide an estimate of what it is going to cost without risking getting anybody out of joint, I would sure appreciate knowing those numbers.

Mr. KAMMER. Certainly, sir.

[The information follows:]

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(formerly National Bureau of Standards)
Gaithersburg, Maryland 20899
OFFICE OF THE DIRECTOR

APR 3 1989

Honorable David E. Skaggs
House of Representatives
Washington, D.C. 20515

Dear Mr. Skaggs:

This letter is to bring you up-to-date on the reconstruction of the cryoelectronic metrology clean room located at the National Institute of Standards and Technology (NIST) Boulder, Colorado, site that was destroyed by the fire in December, 1988. The facility provided a controlled environment with respect to temperature, humidity and dust.

The clean room and all of its contents were a total loss. These include the walls, flooring, ceiling and utilities; eight vacuum workstations with over 60 electronic control systems; and general laboratory equipment to process thin film materials.

The total estimated cost of restoring the facility is $3.6 million. Currently available are portions of the $2 million in unobligated funds intended for work in Boulder, Colorado, carried over from FY 1988, which were earmarked for the superconductivity program in the FY 1989 Appropriations Report 100-979. The base funds of $2.8 million are assigned to work in both Boulder, Colorado, and Gaithersburg, Maryland, laboratories. The President's budget proposes a total program level of $3.5 million for superconductivity (an increase of $700 thousand) in FY 1990. This increase will be assigned to restore the facility and get the program back on schedule as soon as possible. Work will begin on a limited basis in the clean room by August.

Strict deficit reduction targets preclude supplementals without offsets. Maintenance of the other NIST programs is equally important; therefore, I have decided against proposing a reprogramming from other programs. At this point, we will have to use our superconductivity funding to restore the laboratory and delay the research work until repairs are complete. An emergency supplemental will not be proposed.

If I can be of any further assistance, please do not hesitate to ask.

Sincerely,

Raymond G. Kammer
Acting Director

Mr. SKAGGS. Have you been able to identify, given what you're facing here, what the expected delay on superconductivity programs in the Boulder laboratories will be as a result of the fire?

Mr. KAMMER. Yes, sir. I will call on Dr. Lyons in a moment because most of the electronic device work, which is what this is central to, falls in his area. But the short answer is it is profound and extensive.

Mr. SKAGGS. Profoundly extensive?

Mr. KAMMER. And extensive, yes. Almost all of the programs that we have in electronic devices were dependent on this laboratory in particular.

Mr. SKAGGS. Dr. Lyons.

Dr. LYONS. I think it's typical of fire disasters, Mr. Skaggs, that the real cost is not in the replacement of the lost equipment, but the lost time. In this case it's particularly aggravating. This was the facility that made the thin films, put down thin films which are necessary to make devices, whether it be low-temperature superconductivity, which is an area we have been in for 15 to 20 years, or the new high-temperature materials.

We have taken some of the vacuum systems and scrubbed them down and cleaned them up for a short-term measure. We need to replace some of those. They will be able to make some films in a matter of a couple of months, and come summer, as Mr. Kammer said, we ought to have some equipment back in the clean room.

The problem with some of our applications, such as our array junction voltage standards, is that they are essentially integrated circuit technology, thin film technology at rather small dimensions, and the reason we need a clean room is that we want to make films that don't have little imperfections in them. If you try to trace circuits over an imperfection, you get an open circuit and the circuit won't function.

We are in particular trouble with our array junction devices. For example, we have successfully made a 10 volt junction device, in fact we made a couple of them, and it turns out that we only have one functioning device left, I think, probably in the world, and we can't make another one until this new clean room facility comes on. So we are in some difficulty. On the other hand, some of our exploratory work in the new high TC superconductors where we don't want to make these small microcircuits, we can make some progress, but it has been a real blow.

In fact, we have made an assessment, or we're making an assessment of all NIST facilities to see what other areas we may have too many eggs in one basket. We're trying to do a vulnerability assessment now, and we will undoubtedly find other places where from the point of view of disaster planning we need to disperse some of our laboratory facilities.

Mr. SKAGGS. And I would assume that in connection with making your best case for additional monies here you have explained further up the line the impact that this is likely to have on U.S. efforts to remain internationally ahead of the pack on this; is that a fair statement?

Mr. KAMMER. That's the basis for our justification in fact.

Mr. SKAGGS. So you have anything in writing that lays out that case that you could share with the Committee?

Mr. KAMMER. I have a pretty extensive discussion in fact of our program and what we intend to achieve from it for the electronic devices laboratory.

Mr. SKAGGS. If I could ask for that to be submitted for the record with whatever expurgations you need to avoid offending your budgetary folks.

[The information follows:]

The following projects were affected by the fire:

- Properties of High Temperature Superconductors - This research effort is to exploit the properties of the new, high-temperature superconductors which work at the temperature of liquid nitrogen. This coolant is very much less expensive than liquid helium, which is needed for ordinary superconducting phenomena to appear. That economic difference opens the door to the potential applications of superconductivity which has stimulated international interest in the subject. This research must wait for full restoration of the clean room.

- SQUIDS (Superconducting Quantum Interference Devices) - SQUIDS are the most sensitive devices available for detecting magnetic fields, such as from submerged submarines. They are used in both civil and military applications. NIST Boulder makes SQUIDS comparable with the best in the world and is presently working with private industry to transfer this technology. Work cannot proceed until the clean room is restored.

- Voltage Standard - These standard voltage chips are the means of establishing the value of the volt in the U. S. and most other advanced countries. They have a rather short operational life, a problem which NIST is working to solve. At present, a continuous supply of these chips is essential for maintaining the country's basic electrical units and calibration services. NIST is the only supplier of these chips in the U. S. We have on hand a supply of 1 volt chips sufficient to continue present projects, assuming prompt restoration of the clean room. Only one working 10 volt chip remains in the world. This chip provides the most accurate means of evaluating the correctness of certain high-performance electrical measuring instruments. This chip is not currently available to the public.

- Niobium Trilayers - The reason for the short life of the voltage chips mentioned above is that they are currently made of materials which eventually fail from the effects of moisture. Devices made of the metal niobium are expected to be much superior in this respect. This research is aimed at developing in-house abilities to make improved devices using niobium. The goal of this project is the development of a new fabrication process that will be used for all the above projects. The work requires the fabrication of complex test circuits in the restored clean room.

- Analog/Digital Converters - These devices convert electrical signals into digital forms needed for many purposes, such as for high-speed optical communication. NIST also uses them for analysis of very fast electrical signals. This laboratory has built the fastest A/D converters in the world. Progress in development of these devices has halted. The clean room must be restored before work can continue.

- Infrared/Microwave Power Standards - This project is to significantly improve our abilities to measure precisely both infrared (invisible) light rays and microwave signals. Both are of great military importance for electronic intelligence work. About two-thirds of the support for

this work comes from the DoD SDIO. These measurement devices are sufficiently complex that we cannot fabricate devices until the clean room is fully restored.

- Ultra Small Junctions - This research is focused on exploring the physics of behavior of superconducting devices. Fundamentally new effects are being discovered which promise to greatly improve the determination of the values of the fundamental physical constants. These constants are the underpinning of all physical measurements. Other benefits may include reducing the size, and thus increasing the speed, of many of the other kinds of devices mentioned here. Work must wait for full restoration of the clean room.

- Lightwave Metrology Projects - The two projects that are affected are the fabrication of integrated optical waveguides in lithium niobate and the development of fast detectors, both needed for measurement development for optical communication. The projects suffered from the damage of equipment located in the clean room, but do not need the ultra-clean environment per se. They can proceed after replacement of the equipment.

Mr. SKAGGS. Any possibility of getting outside agency help for you, since I understand that some of the work done there was DOD supported?

Mr. KAMMER. We have talked with a number of other people and, John, I think you probably should answer that.

Dr. LYONS. The specific question that we looked into early on was whether we could go up the road to Ball Brothers Aerospace and use their facilities. For a while we thought that would be possible, but the fellows in the lab have concluded that that would not work out. There are too many difficulties in moving things back and forth even though the distances aren't far. Also, I think they feel that they can get some facility going early on. There is a cooperation there with Ball Bothers that I think works out very well.

As far as getting financial support, this program does get financial support, but I don't think we can get help in moving films back and forth say back here in the East. That doesn't seem to be a workable alternative.

Mr. SKAGGS. I was I guess being more blunt than that. Is there any DOD money that can be sent your way to help with the repair work?

Dr. LYONS. Oh, we're working on that problem, sir, as we always do.

Mr. SKAGGS. I would appreciate being kept advised on that aspect of it as well, if you would, please.

Mr. Chairman, I don't want to abuse my time.

Mr. WALGREN. Why don't you take one more and then we'll go to Ms. Morella.

Mr. SKAGGS. I guess a generic question. If you could assess how successful you're being now in instilling a kind of culture in your line people on this whole tech transfer area so that one of the first things that they ask themselves rather than one of the last things that they are forced to be asked is how can I make what I'm doing useful to the commercial private sector in this country. I understand that's a long-term process, but I'm interested in how well you are doing and how you are doing it.

Mr. KAMMER. I think at the risk of being slightly immodest, the Bureau of Standards' history, now NIST, has incorporated for many, many years the ethic of working with the private sector, if you will. Our professional staff amounts to roughly 1,500 people, professional and technical staff. In addition to those individuals, we will have during the course of this year over 1,100 individuals who will work for substantial periods of time, including the full year in many cases, at the NIST laboratories here and in Boulder. These individuals are not paid by us. They are paid by their sending organization. Over 200 of them will be specifically industrial and, incidentally, about a third of those are small business; and another 600-and-some are from the academic community and the remainder are visitors from overseas.

If you think about it for a minute, our culture starts with standards and measurements, and they aren't of much value unless everybody knows about them and uses them. So we have a starting point that tells us that we have to go tell others.

When the first series of Acts were passed by this Committee, the Stevenson-Wydler Act comes to mind, we made an assessment

then, as I think we are now required to every year, of the level of effort that we have provided. In that first year our technology transfer effort was a little over 15 percent, if memory serves, and it remains quite high. It's part of everybody's assignment and it's impossible to be a project leader at the Bureau without having as part of your performance agreement, if you will, an assignment that includes working with the outside world—industry, and we view industry as our first clientele.

Mr. SKAGGS. I'm glad I could throw you a softball as the last question.

Mr. KAMMER. It was great. [Laughter.]

Mr. WALGREN. The Chair recognizes the gentlelady from Maryland, Ms. Morella.

Ms. MORELLA. Thank you, Mr. Chairman.

I'm sorry I'm here late for this very important briefing with people who are very familiar with me and I with them, and I'm so very proud to represent a portion of the National Institutes of Standards and Technology in Maryland's 8th Congressional District.

I do want you to know that I came from a meeting of compensation and employee benefits dealing with the Federal work force. So, indeed, I was there plugging for equipment and retention, and I used as an example NIST and what is happening there and the needs that we have for recruiting and retaining. But I wanted to come over here to simply recognize that I am proud of what you are doing, and this Committee is a great one, this Subcommittee for assisting in any way that we can.

I am curious about this personnel project that NIST has, and I wondered if you might comment on what is happening with that, and I think NASA is looking at it now, too. If you would, I would appreciate it.

We are going to miss you, Dr. Ambler. Are you behaving at Commerce? [Laughter.]

Dr. AMBLER. It's hard to do otherwise. [Laughter.]

Mr. RITTER. How can you get anything done if you behave. [Laughter.]

Mr. KAMMER. The personnel demonstration project was first authorized by Congress about two years and three months ago, and we embarked a year and three months ago on the implementation of it. Having taken a year to plan it, as we were instructed by the legislation.

Having had roughly a year or a bit more's experience under it, the single largest benefit in my personal point of view is not compensation flexibility, although we have that at least up to the ceiling and that's a great help, but it has changed our ability to hire technical professional staff from 18 weeks to 2 weeks. We are talking about 16 weeks of effort that we no longer have to go through. Our experience was, and it wasn't that we begrudged the effort, that was the system we all grew up in and we didn't ask ourselves really any different, but we lost an awful lot of people during that process.

Probably more important, our current opinion at least is that it is probably more important than any big dollar change that you can make is the ability to make a commitment and honor it rapidly

and move the person onto your site while they are interested in you and while they have talked to you and before they have talked to someone else who pays more and also has interesting work.

The flexibility of compensation, interestingly enough, as I just mentioned we have pretty much wide latitude up to I guess it's about $80,000 now, or whatever the ceiling is.

But something that I was personally unaware of when we started on this project is sort of the inertia that is introduced into the system by most your staff is already paid at some level, and if you were to bring an individual in and they started say 3 years later than other employees that you had and you wanted to pay them what they employees that had been there three years were now making, you would probably create a management problem that you'll never dig yourself out from under.

So you find that you aren't as quick to go for the compensation tool as I imagined we would be. That has been a less influential issue than I originally believed it to be.

But the flexibility to hire and the flexibility to classify people without going through the elaborate system that previously required reviews at successive levels outside of the Bureau of Standards and therefore the level to promote, the ability to promote with relatively straightforward predictability, it saved us time and effort, but it has made us a more attractive place to work as well.

Ms. MORELLA. I'm pleased to hear that, but I am surprised to hear that the compensation facet of it is one that you use very gently by virtue of what it may do to the morale of the others, and yet I would think that would be a big clout or a big power instrument.

Mr. KAMMER. The availability of money is also a fairly profound influence on us. But it really turns out to be a decision, and many of the people we hire are of roughly the same description in that they are a recent Ph.D. graduate in a physical science, and when we hire one, we typically are hiring them into a group where there are people that would regard themselves as of roughly the same description, and you can really create a very severe management problem as well as financial problem if you don't go slowly.

Ms. MORELLA. I appreciated your meeting with me and other people from NIST and with Congressman Walgren with regard to the community concept with the nuclear reactor. Maybe you would like to just briefly tell the Committee what you have done to work with the surrounding communities to avoid any concern in the future.

Mr. KAMMER. Well, of course what we are beginning to talk about is in August of 1987 there was a leak of the cooling fluid contained within the reactor at the NIST into the cooling system that is normally tap water, and the radioactive material was then diverted into a holding tank and it was ultimately over the course of about a month and a half released into the atmosphere and into the water, according to an NRC procedure, and we were able to do it in such a way that we were in excess of 100 times below the allowable limit by the NRC.

In this process we had advised the NRC orally, and we followed that up about two months later with written advice to the NRC, in

our minds not having viewed it as a substantial release under the criteria that the NRC normally uses.

Subsequently, there was some discussion of this that came to public attention, a month and a half ago perhaps, about 18 months after the event; I learned something I hadn't known previously, and that is when you use reactor and leak in the same sentence it causes public concern no matter what.

To allay that public concern and in aid of that of course, as you know, Ms. Morella, you and Congressman Walgren asked us to call on you to explain what had happened, which we did, and what we were doing about it; among the things that you expressed concern about then was that we make sure that the local community not be in the position of hearing about events, no matter how benign they might ultimately be, in such a way as to cause them concern. Which is to say, hearing about it for the first time by reading about it in the paper.

Ms. MORELLA. You say it so well.

Mr. KAMMER. We have invited Mr. Kramer, who is the County Executive, and also the individuals in the Montgomery County Government who are responsible for environmental protection and making sure that the population of the county is safe. Mr. Kramer, in fact, is visiting us today and the environmental people have been scheduled and have had to reschedule.

What we plan on doing is coming to an agreement with them, and at the same time satisfying the desires of the Committee, that when we make a written advice to the NRC, and there are prescribed conditions under which one is supposed to do this as an operator of a reactor, that we will at the same time make that same advice to the Committee and to the local community and provide whatever attendant explanation seems appropriate to help people appreciate it in context; and I expect to be in a position where we have discussed this with all the concerned parties in the next week or two and we can commit ourselves to this.

Ms. MORELLA. I thank you very much for explaining that to the Committee.

Just as a final question to Dr. Johnson, I know you've been involved with the State and local initiatives and the clearinghouse concept, and you may want to comment on that if there is something you haven't already commented on before, but you might also want to tell the group about you are heading, what an education committee for the County Government that links up, you know, NIST with County Government with education in that concept.

Could you give us a synopsis of that? I just think it's so laudatory.

Dr. JOHNSON. I'll make just a quick comment on that. It is a private sector, public school partnership in Montgomery County where I think we are plowing some new ground. It's a partnership that I think was established with the support of the County Government about 5 years ago. There are now 60 corporate members of which NIST is one of the early members. Many of the other large organizations in the county, like IBM and Vitro and Bechtel and so on are corporate members. NIH is also a participant.

The sole purpose of that organization is to share in-kind resources, not money necessarily, but in-kind resources with the public school systems to help improve both the education of our children and the education of our future employees. NIST has been very active in this area, both in Boulder and in Gaithersburg, for a very long time. In fact, our program in Boulder, which is called the Care Program, is the oldest of the two programs that we have.

We decided about 5 years ago that it would be useful to us at NIST or then NBS if we could work more closely with the school systems administration to help them get better organized to receive what we were offering to them, and that was a common feeling among the industry participants with the school system. So for those companies that joined the Montgomery education in the beginning, our purpose was to educate and to organize ourselves so that we could better serve the school system and also help the school system organize and better receive that support.

As it stands now, it is a very extensive partnership and it's working very, very well. We offer services of 90 of the NIST staff people to provide classroom lectures and presentations to schools from elementary school through senior high throughout the county. We do that on a request basis, and the requests are funneled through a computer maintained access list which is maintained in the county's central administration office. That is part of the county's attempt to help organize. The computer was donated by IBM and the software was written by Vitro. NIST is a major participant in that process as well.

Last year we provided about 250 individual classroom presentations and lectures from NIST. We also offer classroom material and we loan equipment to the school system. We have been the home of the Montgomery County Science Fair for 15 years, and that is now part of the program that we have offered through the education connection.

We also orchestrate tours for classes of all kinds on all kinds of different topics ranging from specific scientific topics deal in that case primarily with high school science classes to other more general science or even business topics, and in some cases dealing even with elementary school classes.

So it is a rather interesting partnership and I think it's working extremely well. Last year the Montgomery education connection received an award from the National Association of Public School Administrators as the best public school private sector partnership in the country for large school systems. So I think we have something that we can be very proud of. By the way, I happen to be this year's current president.

Ms. MORELLA. Well, congratulations to us that you are, but I wanted you to briefly explain it to the Committee because Chairman Walgren and this Committee are going to be looking at some initiatives, and one that he has sponsored with regard to competitiveness through education and science and math, and I think this a good example of that.

Thank you for allowing me so much time.

Mr. WALGREN. We all wish we had that facility in our districts.

Mr. RITTER. We're jealous. [Laughter.]

Mr. WALGREN. The Chair recognizes the gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thank you, Mr. Chairman.

Just talking about the budget for a minute, how does the adjustment to base compare with the actual increase that you face or you expect in your costs, and how has this worked in previous years?

Mr. KAMMER. The adjustment to base that we're proposing for this year is about $800,000 net, and it's made up of a number of puts and takes, which I'll find in a second. The nature of the last couple of years' experience has been that the government have as a whole had pay raises that were decided upon on a government-wide basis, COLAs, and then there have been decisions again on a government-wide basis that those would not be funded, and this is not unique to NIST, and it's not unique to the Department of Commerce. It's just how it has been.

Over the past few years the accumulation of those has become fairly substantial. I can't really say much more than this has been a decision that the government as a whole has made about how it's going to operate and we have to take it into account and plan for it now. So adjustments to base are becoming somewhat less of a feature of everybody's future.

Mr. RITTER. How much does it actually cost you from year to year?

Mr. KAMMER. It's about a five percent difference from year to year. It's roughly inflation as the normal kind of a change.

Mr. RITTER. And you have to swallow that pretty much?

Mr. KAMMER. That has been the nature of the last few years' experience for us and for all of the Department of Commerce. I'm not familiar with the whole government, but that has been generally the experience.

Mr. RITTER. Dr. Schwartz, where does this country stand in the optoelectronics area and the photonics field? Are we going to be competitive over the decade as new technologies and new devices are developed that begin to replace the more traditional electronic devices?

Dr. SCHWARTZ. Mr. Ritter, I would like to make a brief response to your question and then pass the microphone down to Dr. Lyons.

Much of the activity at NIST in the area of devices and their relationship to optoelectronics is going on in the National Engineering Laboratory which has responsibility.

In the very long term there are issues associated with the materials that will be used in those optoelectronic devices and we have some activity at NIST.

Mr. RITTER. How competitive are we with the Japanese?

Dr. SCHWARTZ. In the very fundamental science area, as in many other technical areas, we are quite competitive, but we are beginning to fall behind because the R&D money that comes into those long-term technical activities has to come from near-term sales, and as we fall farther and farther behind in our competitiveness and the general information areas in semiconductors and so on, those are the areas that bring in the resources to companies which they can devote to the long-term investment.

Mr. RITTER. The Japanese have a major MITI-defined consortium in this area. They have added just recently in the last couple of

years, I think, four or five new companies. It reads like the Who Is Who of the Japanese electronics, telecommunications and information industry. Are we going to wake up one day and find out there is another VCR on our door step or another HDTV situation? Are we anywhere near critical mass to handle this kind of organized, competitive thrust that the Japanese have put together?

Dr. SCHWARTZ. We began very well ahead of course with the introduction of fiber optics, and there is every reason to believe that we are going to be slipping behind, but I really would like to ask Dr. Lyons to respond to this.

Mr. RITTER. I say this as the representative of a $100 million Bell Labs operation, the Solid State Technology Center, which has just gotten going in the Lehigh Valley of Pennsylvania put together by Bell Labs and AT&T. But it seems that they are kind of out there solo while a bunch of AT&Ts, a dozen or so, have really gotten together to get to these plateaus at which point they will assault the peak. You know, it's deja vu all over again.

Dr. Lyons.

Dr. LYONS. Yes, Mr. Ritter. The Subcommittee held a hearing on this subject at Rome, New York eight or nine months ago, and I submitted testimony on behalf of NIST at that time. The real question was the competitiveness of the fiber optic communication business. There was some discussion of fiber optics in computers and sensors as well, but primarily we were talking about telecommunications.

Mr. RITTER. You've got to include in there the solid state devices that could replace semiconductor technology, right?

Dr. LYONS. Yes. What we said was that we thought in terms of science we were doing very well as is typically the case, but in terms of going to market and going to market rapidly and competitively, we were not doing so well. Thank goodness, we have Bell Labs or the picture would be worse.

We have looked at the situation in Japan, and in fact we have a cooperative agreement with NTT, which in many respects is the wellspring of their technology in this field.

Mr. RITTER. At this point it's NTT, Fujitsu, Mashusta, Fugi, I mean you name it.

Dr. LYONS. Et cetera, et cetera, it's a long list. We have looked at some of the cooperative ventures in optoelectronics, and I find them very impressive in the laboratory.

Mr. RITTER. Let me just add here, I think there is a perfect possibility. I mean given the nature of the Advanced Technology Program, and that's going to get me to my next question, wouldn't this be a wonderful area to take the legislation and run with it and put together some kind of synergistic approach to this what we know, and it's like, Dr. Lyons, you know what these emerging technologies are. I mean we know there is going to be a change in how the world communicates and telecommunicates. Wouldn't this be a perfect opportunity for the Advanced Technology Program?

Dr. LYONS. Well, I think you're quite right. It's one of the emerging technologies. In any one of a number of policy scenarios that I've seen, certainly this area would be one of the subjects to be addressed.

Mr. RITTER. Well, what is NIST doing about that?

Dr. LYONS. NIST in my operation has had for some years initiatives before the Subcommittee which you have managed to authorize in increments over I guess four cycles now, and we have another one in the FY-90 budget. We originally defined a $10 million program for our kind of services and, as you know, these are the supporting technology services, and it was a very comprehensive proposal that covered all of the components in the communications system in terms of the supporting data that industry needs to go to market fast and at high quality.

We will have gotten to about half that I think with this year's initiative, and I propose to come back with the rest of it again until we get up close to that $10 million. That is not, however, what you're talking about, which is probably the Japanese approach.

Mr. RITTER. Right now it's in the authorizing legislation. This Subcommittee, this Science and Technology Committee has sought to give the National Institutes of Science and Technology some running room to do with the civilian sector what, to some extent, DARPA has done vis-a-vis the military, although by default has taken charge in some civilian technology as well, and really to counter the synergisms that we find in the Japanese economic system.

What's the story? Are we going to be able to use the Advanced Technology Program for creating these wholes that are greater than the sum of the individual parts?

Mr. KAMMER. Sir, I think the new team, the new Bush team and Secretary Mosbacher, they haven't yet had an opportunity to really address these issues and we don't really have a firm policy basis. The current budget proposal, as you know, sort of throws the question of the existence of the ATP into question, and we need to learn from our new bosses what their desires are going to be before we are going to be able to give you much of an answer about the future.

Mr. RITTER. OK. I would just close by saying that this Committee, and this subcommittee in particular, authors of this activity are very interested in seeing movement on what we feel is a critical issue. We are just creating basic research, but when it comes to transferring it and transferring it rapidly and getting it into products and markets, it's like a boxer, you're in a ring and you're ready to hit because you're really big and strong, but somebody is out there with a right hand between your eyes before you've lifted your gloves.

One last point. You had also talked about quality, but NIST has a responsibility now to serve as a repository and an information transfer agent. Has anything emerged out of that? And I apologize. I know the Trade Bill throws a lot of new balls over the plate at the same time and the money is actually declining to do the overall job. I think it's ridiculous in this day and age, but the nature of the Federal budget is ridiculous. Could you just respond.

Mr. KAMMER. Is this the clearinghouse topic?

Mr. RITTER. Yes.

Mr. KAMMER. Dr. Ambler or Dr. Johnson should respond.

Dr. JOHNSON. Well, let me make a general comment about the Clearinghouse. This of course is a responsibility which is centered in Dr. Ambler's area in the Department of Commerce. That's

where the clearinghouse will actually be operating. We have a role to play in that and in fact have been working very closely with some of our colleagues in the Department to plan out the functions of the Clearinghouse.

Our role initially is going to be to establish the initial database from which the Clearinghouse will base its activities. That database is being established by a survey of all of the state government funded extension activities nationwide. We have identified more than 450 different State programs that provide extension and outreach services and we have designed a questionnaire in partnership with the National Governors Association that will provide us with a range of information on everything from incubators to research parks and a whole lot of financial information on how the States are funding different kinds of technically oriented economic develop activities.

Mr. RITTER. But there was also a separate clearinghouse activity to begin to generate information quality and the quality revolution.

Dr. JOHNSON. Oh, you're speaking about a quality clearinghouse?

Mr. RITTER. Yes.

Dr. JOHNSON. I'm sorry, I was on a different track. In the quality area we are gearing up now for the second round of competition and assembling what we have learned from the previous round, and I can tell you what I know about it and I think maybe Mr. Kammer has better information than I have, but there is a great demand on our staff there to give public presentations and discuss what we have learned from the first round of competition and I know that Curt Reiman is out today doing that. So there is a lot of information being disseminated that has been derived just from the competition this year itself.

Mr. RITTER. I appreciate that, and I just want to reiterate there is in the Trade Bill amendments, a quality, per se, beyond the State programs, which are important in their own right, but this is something else where there is a responsibility in, I believe, in the reorganized NIST to generate best practice information. And I think the language is quality and productivity and to begin to get some kind of information base that I believe that you can use as you generate your relationships with industry, whether it's manufacturing centers, whether it's your outreach to the schools in this wonderful sounding program which I wish we had in our Lehigh Valley in the 15th District of Pennsylvania.

But if you don't start getting the facts together and building on what the Baldrige Award gives you, you're not going to be really able to integrate this into these other situations.

Mr. KAMMER. I somewhat just didn't associate the word clearinghouse with it. So I was going down a different track.

Mr. RITTER. Because you assumed the State program technology transfer clearinghouse was what was meant.

Mr. KAMMER. We have in fact begun to accumulate the information and we are trying to disseminate it, and we are working with two contractors, the American Society for Quality Control and then the American Productivity and Quality Center, and they are very good people.

Mr. RITTER. Good.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Ritter.

The Chair recognizes the gentleman from Colorado, Mr. Skaggs, for any further thoughts.

Mr. SKAGGS. Just very quickly. Thank you, Mr. Chairman.

I don't remember, and I should, is it contemplated that there will be a further competition for additional centers beyond the three that were selected last fall?

Mr. KAMMER. The legislation that created the centers, if you will, contemplated up to 12, if memory serves. The current funding would simply stop with these three centers. The first three are funded for this year and next year.

Mr. SKAGGS. And do you have a plan based on early experience with these three determining if and when to push for additional funding for the remaining nine then?

Mr. KAMMER. In the 1990 budget process there was considerable consideration of that and discussion of it, and the conclusion then was not in the 1990 budget process.

The nature of the budget policy decisions that I presume will be made in the next three or four months will probably tell us a lot about what happens after that.

Mr. SKAGGS. So nothing is imminent at any rate.

Mr. KAMMER. Right.

Mr. SKAGGS. Finally, in your prepared statement you indicated that all of the reports referencing reports that Congress had asked for are completed and will be available shortly. Does that include the report or study that we requested for the advisability of establishing a technology transfer operation out of your Boulder laboratories?

Mr. KAMMER. Let me look. Yes, sir.

Mr. SKAGGS. And when will those be sent up?

Mr. KAMMER. They are in clearance now. The commitment I have from the different people that are clearing it that they hope to get it done soon, but soon is not a number. That's the best information I have. So it's the best information I can give you.

Mr. SKAGGS. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Skaggs.

Well, let me on behalf of the Committee thank all of you. We have some follow-ups that we would like to give you in writing, but I think we have pretty well exhausted our staying power today.

I want to especially express again appreciation on behalf of all of us, Dr. Ambler, for all of your service over the years and wish you the very best in your retirement. We know you'll be staying around Washington, and we expect to see some of the things you might write and some of the presentations you might give. We want you to be a continuing resource to us and we, as I say, express appreciation for all you have done.

Dr. AMBLER. Thank you very much.

Mr. WALGREN. Thank you.

With that, we will conclude.

[Whereupon, at 1:15 p.m., the subcommittee adjourned, subject to the call of the Chair.]

# DEPARTMENT OF COMMERCE TECHNOLOGY PROGRAMS

WEDNESDAY, MARCH 8, 1989

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
*Washington, DC.*

The Subcommittee met at 9:45 a.m., in Room 2226, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Campbell, Brown, Buechner, Morella, Skaggs, Boehlert, and Schneider.

Mr. WALGREN [presiding]. I want to welcome you all here today to this second day of hearings to the Department of Commerce's Technology Programs.

As you know, this Subcommittee feels a very strong sense of frustration at this point in our process.

In March 1987, we began the process of enhancing the technology missions of the Department of Commerce.

We spent a long time, 16 months, pulling together the various elements on the Hill into the ability to agree on the Technology Competitiveness Act portions of the Trade and Competitiveness Act. That became a landmark bill which, among other things, reconstituted the National Bureau of Standards as the National Institute of Standards and Technology and gave that agency a lead role in providing support to those portions of our civilian economy, which are both under attack from foreign competition and which provide the hope for a healthy economy in this country in the next decade and beyond.

We were very careful to include the Reagan administration in our negotiations, and we made a number of changes in the process of this bill to make it acceptable to them.

When the bill became law, we had high hopes that, finally, as we turned into the 1990s, we could move ahead and begin to provide the kind of support to American companies that is provided to science-based commercial activities in the countries which are our greatest competitors.

Also, in 1988, at Secretary Verity's request, we carried that process a step further by creating a Technology Administration in the Department of Commerce, particularly creating an Under Secretary for Technology in order to create a high-level of technology agencies. We hoped to establish and further the mutual goal of giving technology policy and technological assistance to American

industry the high level of attention of our executive branch, which is the broad consensus that it deserves.

Unfortunately, the budget politics of the transition from 1988 into 1989 appear to have derailed that consensus. An inflexible freeze which essentially excised from the Reagan budget all the Commerce technology programs which originated in the Congress now confronts us.

While on the one hand, an "us versus them" approach may be one way to negotiate with people like OMB, it is certainly not a helpful strategy for the country as a whole. It seems to me that we must recognize that the ways of doing things in the past, particularly the sharp divisions between the federal role on the one hand and the private sector role on the other, are not the best way to go forward. If we do not essentially modernize our thinking about the role of government to provide the American private sector with the resources they need to compete against the kind of competition that is coming from overseas, we will, I'm afraid, miss out on the vast payoff that these technologies promise.

Certainly, all is not pure gloom. We have been encouraged by the public pronouncements of Secretary Mosbacher, the new Secretary of Commerce, and we realize that the Bush administration officials who will ultimately make or break these kinds of programs for the most part have yet to be named.

We hope that the budget that has been sent to us thus far turns out to be simply a relic of the past. We all recognize that, from the Congress' standpoint, you can lead a horse to water but you cannot make it drink.

The key to any success lies in the approach which will be brought to this area by those executive officials that ultimately are given that responsibility in the Bush administration.

I ha· e been struck deeply by the fact that at every point when someone accepts responsibility for the outcome in these areas, they come away with a much more creative and--I don't know what the other word would be—approach to the role of the Federal Government in science and technology.

With respect to the private sector, whether it was Mr. Packard when he approached the studies of the National Laboratories, expressing in many ways great reservation, and after he had grappled with that responsibility came away with what was in many ways a wringing endorsement of the importance of the efforts that the National Laboratories make to the progress in the private sector.

Whether it was Jay Keyworth who, as science adviser, approached our system at a time when we were essentially walking away from the role of science education in the National Science Foundation, at the end of his term, we not only were not walking away from it in his view, but had reestablished the directorate involved and are increasing the funding rather than decreasing.

Wherever you look, you will find people who have grappled with this, like John Young on the Competitiveness Council, coming away with strong feelings that the Federal Government has a critical, essential and proactive, positive initiative, which must be taken on the Federal level if the national interest is to be served best.

Today's testimony will be given by expert nongovernment witnesses. The focus will be both on the administration's proposed budget initiatives and on the various Commerce Department technology programs that we authorized in the last Congress.

The first of today's three panels will focus on the Advanced Technology Program, which was designed to help U.S. high-technology ventures compete with overseas competition that is subsidized with their governments.

The next panel will cover the new initiatives proposed by NIST, by President Reagan's budget and by the Steel and Aluminum Energy Conservation and Competitiveness Act of 1988.

The final panel will discuss the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation, whose purpose is to assist State and local governments to meet the competitive needs of American business on a local level.

I want to say at the outset to all the witnesses that we will have today that we really do value both your views and the time and seriousness of purpose which you bring to participate in our process. And we are grateful for your help in creating a record that will help others sort through this area.

With your help, we hope to gain both the information and the insights that people on the Congressional level need to work with a new administration. We hope that the new administration, whoever they are, will look very carefully at the kinds of perspectives that you bring formally to our public process in shaping their own approach to their responsibilities.

So that, ultimately, we can develop policies and programs in this country that will not only see us out of our trade deficits, but see us into a very bright economic future for our country ahead.

With those thoughts, let me recognize the gentleman from California, Mr. Campbell, for any opening comments he had and then the gentleman from California, Mr. Brown, for opening thoughts as well.

Mr. Campbell.

Mr. CAMPBELL. Thank you, Mr. Chairman. I wish to applaud the chair for conducting these hearings at this juncture. I think the jury is still out as to what the administration intends to deliver on its promises for the high-technology in science development.

I obviously am willing to take the leadership of the administration and I think one of the benefits of a hearing such as this is to try to focus some energy on what we expect from the administration.

So I applaud the Chairman for holding these meetings early. I do, however, hold the view that the jury is out until we have a National Science Adviser and the President gets his team fully in place, we might suspend, at least critical judgment.

The other point I would like to make just by way of introduction is that I very much look forward to reviewing and hearing the testimony today, particularly from the point of view of how America can compete in high-technology without becoming another Japan.

But, to use the special aspects of the United States economy, namely, its entrepreneurial base, hopefully, joint ventures, hopefully, consortia; the ability of firms to work together is something

unique to America and we don't have to become an exact replica of the Japanese model.

With that, I yield back my time, Mr. Chairman.

Mr. WALGREN. I thank the gentleman.

The gentleman from California, Mr. Brown.

Mr. BROWN. Mr. Chairman, thank you. I regret that I was not able to be here yesterday for the first day of this series of hearings. And I'm looking forward to today's hearings.

I would like to ask unanimous consent to insert a statement in the record from yesterday's session.

Mr. WALGREN. Without objection.

[Mr. Brown's opening remarks of March 7, 1989 follow:]

OPENING REMARKS OF HON. GEORGE E. BROWN, JR. (D–CA), HEARING ON DEPARTMENT OF COMMERCE TECHNOLOGY PROGRAMS, MARCH 7, 1989

Mr. Chairman, I want to express my support for the Department of Commerce's efforts to enhance the role of technology policy in overall economic policy formation. The designation of an Under Secretary of Commerce for Technology within the Department is a positive step in this regard.

This committee has for many years had a good relationship with the National Bureau of Standards, and I look forward to many more years of work with the Bureau in its new form, the National Institute of Standards and Technology [NIST].

Along with the new name, the Bureau has also been granted increased responsibilities. Unfortunately, this increased responsibility was not accompanied by increased resource commitment. More specifically, the fiscal year 1990 budget request for NIST is more than $3 million below the fiscal year 1989 appropriation level.

It seems that the administration is disregarding the technology provisions of the Omnibus Trade and Competitiveness Act. This committee spent considerable time and effort working with agencies and industry developing a comprehensive measure. I am perhaps most concerned about the Advanced Technology Program. The Advanced Technology Program can provide critical assistance to American industry in such emerging fields as high-definition television technology and superconductivity. Unfortunately, the Office of Management and Budget requested no funds for this initiative.

I am also concerned that implementation of the Metric Usage Act, section 5164 of the trade bill, has been sluggish. I would like to know why the Under Secretary has not provided this effort with clear direction on how to proceed toward implementation. I look forward to hearing about the progress on metrication. We now have the means by which Americans can gradually convert to the metric system. I hope that the administration will give this effort its full cooperation.

Thank you Mr. Chairman.

Mr. WALGREN. Let me recognize the gentleman from Missouri, Mr. Buechner, for any opening thoughts he has.

Mr. BUECHNER. I don't have any opening statements to make, Mr. Chairman. I know that this is a very distinguished panel and I appreciate their appearance before us today, and we have as a Committee and a Subcommittee been extremely concerned with the entire question of what we as a Nation can do to stimulate high technology.

Anything that they can do that will continue America's leadership and to even strike some new grounds, I'm sure we're going to appreciate, and we will work with them to make sure that that becomes a reality.

Thank you.

Mr. WALGREN. Let me recognize our first panel at this point: Dr. Arden Bement, the vice president of technical resources of the TRW Corp.; George Heaton of the Sloan School of Management at

MIT; and Kenneth Flamm, a senior fellow at the Brookings Institution here in Washington.

As I said, we appreciate what you give to these hearings. As you know, your written statements will become part of the record and reproduced in a way that it will be available for all those who work with these kinds of materials and you should feel free to focus any way that you like to highlight points that you would like to stand out in the verbal part of our proceedings.

So, let me start with Dr. Bement.

STATEMENT OF DR. ARDEN L. BEMENT, VICE PRESIDENT, TECHNICAL RESOURCES, SCIENCE AND TECHNOLOGY DEPARTMENT, TRW, INC.

Dr. BEMENT. Thank you, Mr. Chairman, and members of the Committee. I am pleased to appear before the Committee to present my views on the Advanced Technology Program of the National Institute for Standards and Technology. And I wish to stress that the views I bring you this morning are my own and thank you, Mr. Chairman.

I would merely like to highlight some points of my written testimony in the interest of time.

A year ago, I appeared before the Committee and testified that the NIST was in good health and had very exciting prospects for the future. This year, the situation is less clear. While NIST has been given an increased role in enhancing the Nation's technological competitiveness, resources have not been provided to enable many of the technology transfer activities created by the Trade Act to go forward.

As you pointed out, perhaps even more serious is the fact that the present budget situation also threatens the continuity and productivity of the Institute's Science and Engineering Programs on which these technology transfer activities must build.

At issue in the minds of many of the administration officials is: Should the Federal Government play a role in the pre-competitive stages of technology development?

I believe government should play such a role, but I would like to draw a distinction between establishing capabilities in advanced technologies and exploiting these capabilities for commercial advantage.

I don't believe governments are credible agents in the commercialization of technologies, picking technology winners or controlling, targeting, or regulating the flow of technology.

I believe government acts best when it sets long-term national goals and plans, when it assists in building the Science and Technology infrastructure, when it establishes an atmosphere for innovation and private investment, when it provides a catalyst for economic development through loans, grants and tax benefits, and when it acts as a partner with industry in the upstream, pre-competitive stages of technology risk reduction.

Two problems with government investment in the commercial sector are: First, policymakers today still lack a good definition of pre-competitive, what that means, and they lack a sense of when government should let go and allow competitive forces to take over.

These points were highlighted in the debate over SEMATECH, but the need to sustain a strong semi-conductor industry in the interest of national defense prevailed.

Also in the lobbying over SEMATECH, there emerged a fervent interest in DoD participation because of its deep pockets and the presence of an outstanding in-place technical program management structure in DARPA that could assure fast response.

Similar interests and arguments have now led to DARPA, assuming the point position for government investments in such emerging technologies as neural-net computers, high-temperature superconductors, high-definition television and advanced manufacturing technologies.

While such a policy may be expedient, it is flawed to the extent that it attempts to address national commercial technology needs.

First of all, most emerging markets in advanced technologies can bring about wholly new industrial structures. Because of the diverse commercial interests having a stake in these new markets, the Department of Commerce—not the Department of Defense—should play the convener role in determining the long-term and national agenda for a joint government-industry technology investment.

Second, many companies involved in emerging technologies choose not to do business with the Department of Defense for legitimate business reasons.

Third, opportunities for new technology insertion are now occurring more rapidly in commercial products than in Defense products because of ever-shortening commercial product lead times.

Therefore, technology transfer in the future will tend to occur to an increasing extent from the commercial to the defense side of dual-use technologies.

Finally, with the increasing linkage among economic trade defense and technology policies among our world's trading partners, inter-agency participation in working with the private sector in developing global, precompetitive technology investment strategies will become increasingly important.

For these reasons, I believe the time is right for an Advanced Technology Program in the Department of Commerce. I believe that the program, adequately funded and properly managed, can make a strong impact on U.S. industrial competitiveness.

However, there are some serious management issues. The first step of course in creating such a program is to develop a list of national technology priorities, to define what the program is supposed to accomplish. Industry, through the convening role of the Under Secretary of Technology, must take the lead in setting these agendas and priorities.

Once that's done, the pivotal question is whether sufficient funding will be provided to create programs that will make a real difference in our Nation's competitive position.

The level and duration of funding must reflect the realities of technology development. Programs must be large enough, say, on the order of $15 to $20 million per year per technology thrust, and adequately leveraged with private sector investments to set ambitious goals and have a meaningful, timely impact on specific technologies.

In addition, a sustained commitment to multiyear efforts is needed to transition these technologies to the private sector for subsequent commercial exploitation.

The nature of the advanced technology program presents a number of pitfalls to be avoided. The existence of grant money under the program invites micro-management as well as attempts to direct appropriations to specific organizations and individuals.

I believe the wisest and most productive course is for Congress, once it has set the wheels in motion, to turn the program over to technical professionals for implementation.

The Visiting Committee has thought about how this might be done. We would like to suggest that responsibility for funding and contracting be given to the Under Secretary for Technology in the Department of Commerce. NIST would then be responsible for technical management of the specific programs.

This arrangement, which parallels the working relationship between DARPA and the military departments, raises the stature and visibility of the program and gives NIST the responsibilities that it is particularly well-qualified to carry out.

Since the advanced technology program is a new world for NIST, DOC's management should be encouraged to be flexible and pragmatic in implementing this Trade Act mandate; and also to be patient.

I would like to leave you with a final thought. There's a strong belief both inside and outside NIST that its traditional mission in scientific and engineering programs are essential to the national interest and deserve the highest priority for funding.

I share that view. If Congress chooses to fund technology investment activities such as the advanced technology program, that are not included in the President's budget, these new activities should be considered incremental and should not be funded at the expense of established NIST activities.

Speaking plainly, it is unwise to risk irreparable harm to research programs that I believe have high leverage and which have demonstrated their worth over the years to fund new activities—no matter how worthy they may seem to be.

Mr. Chairman, this concludes my opening remarks.

Thank you very much.

[The prepared statement of Dr. Bement follows:]

Statement of Dr. Arden L. Bement
Vice President, Technical Resources
Science and Technology Department, TRW Inc.
and Vice Chairman, Visiting Committee on Advanced Technology
of the National Institute of Standards and Technology
Before the Subcommittee on Science, Space and Technology
U. S. House of Representatives
on Authorization of Appropriations for the Activities
of the National Institute of Standards and Technology
March 8, 1989

Mr. Chairman and Members of the Committee:

I am pleased to appear before this Committee today to present my views on the National Institute of Standards and Technology. I wish to stress that the views I bring to you this morning are my own; they reflect my experiences during a thirty-five year career as a researcher, teacher and manager in industry, government and academia. I have served the Defense Department as Deputy Under Secretary of Defense for Research and Advanced Technology, and as the Director of the Office of Materials Science at the Defense Advanced Research Projects Agency. I have also conducted research and taught at the Massachusetts Institute of Technology, managed reactor materials research at the Battelle Memorial Institute, and performed materials research at the General Electric Company. I am currently Vice President of Technical Resources of TRW, Inc., a corporation recognized as a leader in science and technology. I am also serving as Vice Chairman of the Visiting Committee on Advanced Technology of the National Institute of Standards and Technology.

A year ago, I appeared before the Committee to testify at a time when, in the words of its Director, NBS had "been discovered." The future looked bright, with the impending passage of the Trade Bill giving NBS, or now, NIST, an expanded role in our country's technological competitiveness. I concluded my remarks last year by saying that the Institute was in very good health and had very exciting prospects for the future.

Last year I also testified before the Senate Committee on Government Affairs on Senate Bill No. 1233 – "The Economic Competitiveness, International Trade and Technology Act of 1987". At that time I argued for strengthening the nation's technology base for competitive advantage, for establishing the Office of the Under Secretary of Technology, and for strengthening the role of the Department of Commerce in evolving a Federal technology policy.

This year, the situation is less clear. While NIST has been given an increased role in enhancing the nation's technological competitiveness, resources have not been provided to enable many of the technology transfer activities created by the Trade Act to go forward. Perhaps even more serious is the fact that the present budget situation also threatens the continuity and productivity of the Institute's science and engineering programs on which those technology transfer activities must build.

While I strongly support the new technology transfer responsibilities

that NIST has been given under the Trade Act, I continue to be concerned about our national resolve to set a policy agenda for developing and deploying the commercial technologies critical to America's ability to compete in world markets. Therefore, I am grateful for the opportunity to participate in this panel and present my particular views on the Advanced Technology Program established in the Trade Act.

Basis for an Advanced Technology Program

Technology has become recognized worldwide as a powerful competitive force for economic growth, wealth creation and new job development. Hence, both developing and highly-developed countries alike have increased their national investments in technology because of the broad benefits such investments can bring to the welfare of their societies in general.

U.S. industry is responding to this challenge by taking an intensified global view in conducting R&D, gathering information, forecasting technologies, planning markets, developing new businesses, and searching worldwide for lower-cost sources for materials and manufactured products. However, in nearly every study on competitiveness the adversarial relationship between government and industry in economic, legal and regulatory policies is cited as a major barrier to improving our national competitiveness in global markets. Furthermore, when government regularly changes its fiscal and tax policies it can have a deadening effect on technology development and commercialization.

At issue is: "Should the Federal government play a role in the "pre-competitive" stages of technological development?" The absence of such a role may lead to greater U.S. slippage in the global technological race with serious consequences: (a) a growing trade deficit in high technology products and services, (b) a continuing dependence on off-shore sources for the high-technology products needed to provide our military services with superior weapons, (c) a declining control of high-leverage defense technologies, (d) a growing fraction of our trade deficit representing value added off-shore to our raw materials, and (e) an erosion in our world prestige as a major power. For these and other reasons, I believe the Federal government's role in assuring the nation's technological strength is an imperative for the future.

While I believe government has a role in building capabilities in advanced technologies, I would like to draw a distinction between establishing capabilities in advanced technologies and exploiting these capabilities for competitive advantage. Government acts best when it sets long-term national goals and plans; when it assists in building a science and technology infrastructure by establishing a conducive atmosphere for innovation and private investment; when it provides a catalyst for economic development through loans, grants and tax benefits; when it acts as a partner with industry in the upstream "pre-competitive" stages of technological risk reduction. And when it acts as a buyer and user, it can also help by sharing development costs and by providing long-term purchase guarantees. Governments are not credible agents in the commercialization of technologies, picking technology winners, or controlling, targeting or regulating the flow of technology. If they

attempt to do so —— at best their policies are enlightened or shortsighted; at worst they are counterproductive and dangerous.

While the development of a coherent national technology policy has inherent complications concerning "Who chooses what technologies to invest in?" and "How should the risks and benefits from such investments be shared between government and industry?", the currently operating alternatives are to attack nationally-led, supported and focused programs in Japan and Europe with a broad front of fragmented, sub-scale and duplicative university-industry R&D consortia which address only the earliest stages of demonstrated technical feasibility.

Two problems with government investment in the commercial sector are: (1) policy makers lack a good definition of "pre-competitive" and (2) a sense of when government should let go and allow competitive forces to take over. In the past, when the Federal government did get involved, it generally took control. Unfortunately, it lacked the resources and knowledge of the marketplace to play the controlling role well. Furthermore, it didn't know when to stop. I believe the success of the Japanese government in investing in commercial technologies is that it knows how to participate with industry and when to cut off funding. The M.I.T.I. approach is to get a number of horses at the starting gate at the pre-competitive stage; then, when it's clear that a market exists, to stop government investment and allow competitive forces to take over. Such a strategy is in the interest of competitiveness; it's not anti-competitive.

Many of these points were highlighted in the debate over SEMATECH, but the need to sustain a strong semiconductor industry in the interest of national defense prevailed. Also, in the lobbying over SEMATECH there emerged a fervent interest in DoD participation because of "deep pockets" and the presence of an outstanding, in-place technical program management structure in DARPA that could assure fast response. Similar interests and arguments have now led to DARPA assuming the "point position" for government investments in such emerging technologies as neural-net computers, high-temperature superconductors, high-definition television and advanced manufacturing technologies. While such a policy may be expedient, it is flawed to the extent that it attempts to address national commercial technology needs:

a) Most emerging markets in advanced technologies can bring about wholly new industrial structures. Because of the diverse commercial interests having a stake in these new markets, the Department of Commerce, not the Department of Defense, should play the convener role in determining the long term national agenda for joint government-industry technology investment.

b) Many companies involved in emerging technologies choose not to do business with the Department of Defense for legitimate business reasons.

c) Opportunities for new technology insertion are now occurring more rapidly in commercial products than in defense products because of ever shortening commercial product lead times. Therefore,

technology transfer in the future will tend to occur to an increasing extent from the commercial to the defense side of dual-use technologies.

d) With the increasing linkage among economic, trade, defense and technology policies among our world trading partners, interagency participation in working with the private sector in developing global "pre-competitive" technology investment strategies will become increasingly important.

For these reasons I believe the time is right for an Advanced Technology Program in the Department of Commerce. I believe that the Program adequately funded and properly managed, can make a strong impact on U.S. industrial competitiveness.

What are some management issues?

The Advanced Technology Program has been described as a civilian version of DARPA, the Defense Advanced Research Projects Agency. As a former manager within DARPA, I think that the comparison is a bit presumptuous at this time: DARPA operates with an annual budget of nearly $800M, while no money has yet been appropriated for the Advanced Technology Program.

The first step, of course, in creating a civilian technology program, is to develop a list of national technology priorities to define what the program is supposed to accomplish. Industry through the convening role of the Under Secretary of Technology must take the lead in setting these

agendas and priorities. Once that is done, the pivotal question is whether sufficient funding will be provided to create programs that will make a real difference in our nation's competitive position. The level and duration of funding must reflect the realities of technology development. Programs must be large enough, on the order of $15–20M per year and adequately leveraged with private sector investments, to set ambitious goals and have a meaningful, timely impact on specific technologies. In addition, a sustained commitment to multi-year efforts is needed to transition these technologies to the private sector for subsequent commercial exploitation.

The program will require top talent for both researchers and program managers. These high performers are not likely to commit their careers to small programs with uncertain futures. Furthermore, the roles and responsibilities of ATP program managers must be carefully defined to address the following challenges:

a) What will be the relative roles of the private sector and ATP management in selecting and developing programs?

b) What flexibility will ATP program managers have in qualifying and selecting R&D operations to implement programs?

c) What accountability standards must program managers meet for returns on investments?

d) How do programs get successfully transferred to the private sector?

e) How and when should programs be terminated to allow competitive forces to operate most effectively?

f) How will ATP management assure sufficient program turnover to keep the program dynamic and assure the availability of adequate resources to test new concepts and scale up promising opportunities?

The nature of the Advanced Technology Program presents a number of pitfalls to be avoided. The existence of grant money under the Program invites micromanagement as well as attempts to direct appropriations to specific organizations and individuals. I believe that the wisest and most productive course is for Congress, once it has set the wheels in motion, to turn the program over to technical professionals for implementation.

The Visiting Committee has thought about how this might be done. We would like to suggest that responsibility for funding and contracting be given to the Under Secretary for Technology in the Department of Commerce. NIST would be responsible for technical management of the specific programs. This arrangement, which parallels the working relationship between DARPA and the military departments, raises the stature and visibility of the Program and gives NIST the responsibilities that it is particularly well-qualified to carry out.

The management challenge in this arrangement is to avoid giving NIST responsibility for the results of the program without commensurate authority to decide who its working partners will be. This will require a close relationship between NIST and the Under Secretary, which is

desirable in any case. Furthermore, since the Advanced Technology Program is a new role for NIST, DoC's management should be encouraged to be flexible and pragmatic in implementing this Trade Act mandate.

There is a strong belief, both inside and outside NIST, that its traditional mission and more scientific and engineering programs are essential to the national interest and deserve the highest priority for funding. I share that view. If Congress chooses to fund technology investment activities such as the Advanced Technology Program that are not included in the President's budget, these new activities should be considered incremental, and should not be funded at the expense of established NIST activities. Speaking plainly, it is unwise to risk irreparable harm to research programs that I believe have high leverage and which have demonstrated their worth, to fund new activities, no matter how worthy they may be.

I would like to leave you with a final thought. In a time of limited resources and many obligations, it is natural to look for targets whe xpenditures can be pared. However, expenditures on science and technology that will increase the strength of U.S. industry are investments in our nation's future. We must have the courage and the wisdom to make this investment: our competitors in the world market have already decided to do so.

Thank you!

Mr. WALGREN. I appreciate that, Dr. Bement.
Let's turn to Mr. Heaton at this point, and then Mr. Flamm.

## STATEMENT OF GEORGE R. HEATON, JR., SLOAN SCHOOL OF MANAGEMENT, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Mr. HEATON. Mr. Chairman, members of the Committee and staff, it's a pleasure to be here today and discuss what I consider a very promising initiative. I must confess to some ambivalence though. On reading your invitation letter, while I was delighted to help with this opportunity to implement the civilian industrial technology policies, something I have believed for a long time is necessary, there was also a kind of agony involved.

I'm a lawyer and professor and you must have suffered through our long-windedness from time to time, so 5 minutes seemed a very difficult challenge.

But, thinking further, I decided that the bottom line message was really very simple. And it is:

Let's get on with it.

So I would like to summarize and move a bit forward from that in this brief statement, which is amplified more in the record.

Since the early 1960s, the United States has been what one might call flirting with the idea of establishing an explicit national-civilian technology policy. The ideas inherent in this notion have been slow to take root.

There have been a number of specific program proposals which have garnered insufficient support in the Congress and perhaps the country as a whole that have come to fruition.

In the executive branch, over time, the institutional base for leadership has been somewhat eroded. Even in the early 1980s, when we began to recognize more clearly the relationship between technology and international competitiveness, the country still heard the recurring complaint that we had no civilian technology policy.

As recently as last year, it still seemed germane to complain that there was no locus or institutional home for that policy. Even today, there are some who still suggest we suffer from a lack of coherence in that policy.

My reaction is just the opposite. With the creation of NIST, this Advanced Technology Program, and under the umbrella of the Under Secretary for Technology, I believe that the establishment of the legal authority for a national-civilian technology policy is quite complete.

The structures that we have in place now compare favorably with those in any of our major trading partners. There are no limiting defects in concept. I believe Congress has given the Nation a very clear direction and appropriate institutional structures.

Well, what remains?

Obviously, we need tools, perseverance and vision to get on with it. Congress in particular must furnish the necessary implementive resources. One place to look for some guidance about how to move forward in this endeavor is the structures that other countries have designed to accomplish some of their objectives.

In an appendix to my remarks I've prepared a chart showing programs such as this in Japan, France, Germany, and also DARPA in the United States. This information is based in part on published sources and, in part, on my own research as a visiting professor in Japan and Europe.

In the aggregate, the trend from abroad is quite clear. There is much more than Japan to serve as a model. Each of these countries that I have surveyed possesses a strong effort at the national level in support of civilian technology.

The ATP draws skillfully I believe on some of these models, but it is unique with its own particularly American strength.

Among these programs, the German Ministry for Research and Technology is the largest in size and scope as the Cabinet level Department is the coordinator of the nation's technical enterprise. It has an element very analogous to the ATP, which is a program of direct R&D grants to industry.

While this has been a well-accepted means of industrial subsidy, the BMFT program is subject to criticism for its close connection, perhaps too close a connection, to a relatively small number of large firms.

In France, there is an Agency for Research Valorization, which is a quasi-public venture capital organization much more closely linked to the commercial process than in Germany.

One would have to say that ANVAR exemplifies a mixed record of picking winners in the commercial marketplace.

In Japan, a new program called the Key Technology Center was founded in 1986 as a unique, off-budget, specially chartered corporation from the Japanese Diet, funded with monies that have come from the privatization of government monopolies.

Its focus is in funding on a long-term basic research which may lead in a decade or so to commercial applications.

Key TEC requires, as do many Japanese programs, that its clients cooperate to perform new joint ventures. In contrast to Key TEC, the Agency for Industrial Science and Technology represents the traditional focus of MITI's technology policy. Historically, its principal policy instrument has been to fund the industrial research consortia and to undertake generic pre-commercial activities.

The funding granted by AIST is typically modest for most projects and very much below the industrial level. Thus, its technical impact should not be over rated.

Nevertheless, it sets up a very important system of cooperation and information flow.

Today, however, many in Japan are criticizing or calling for an overhaul in this traditional system in which research is done, as the Japanese sometimes say, by Committee. In the U.S. context, by way of contrast, few would dispute the technical successes that would be credited to DARPA since its creation in the late 1950s. DARPA is often compared to MITI but the analogy really does not hold. DARPA's initiatives have typically been much larger than those in MITI, more driven by a technical position from the government, less by consensus, much less bureaucratic and, of course, in support of the Defense mission, which does not apply to Japan, in considering what this means for the ATP, I would suggest there

are lessons both positive and negative from which it can profit, but that it is already cast in a uniquely appropriate mode and need not be essentially changed.

One important aspect is the placement of ATP in NIST. This program, therefore, cannot play a coordinating role for civilian technology. I do not view this, however, as a limiting factor. On the contrary, it presents ATP with an important opportunity, which is unique among these programs I've surveyed, to draw on a reservoir of technical expertise and, thus, form partnerships with industry that go beyond financial arrangements.

The particular initiative that ATP takes and the style with which they are pursued depend of course in large measure on the character of its personnel and the kind of communication networks it establishes with industry.

Different approaches to this problem are inherent in the foreign models. The German BMFT stands at one pole in assuming mostly a reactive role waiting for industrial proposals. Both the Japanese programs represent the polar case of a different nature in which industry is clearly dominant in technical decision-making.

The American Civil Service and regulatory traditions seen perhaps in DARPA and its very expert staff tend toward exactly the opposite approach.

What seems appropriate for ATP is a middle ground. They of course must have high technical expertise, but their agenda must be responsive to industry needs. The visiting committee on advanced technology is one important mechanism to establish this.

While the creation of NIST and ATP are very promising signs they come at the end of a rather frustrating line of Congressional policy initiatives that have received inadequate implementation.

One is most cautioned, for example, by the history of the Stevenson-Wydler Technology Innovation Act of 1980 in which the Centers for Industrial Technology became nugatory through lack of funding. And in the current budgetary climate there is a real risk of the same fate for ATP.

I believe, however, that there are several major differences between 1980 and 1989 that should persuade us to take a different and much more generous appropriations path. Perhaps most obviously, the increased international competition makes this national imperative all the more pressing.

Second, the industrial perspective on this issue has changed rather radically. Industry now appears committed not only to enter firm cooperation but also to the notion of government participation in joint enterprise.

There are clear opportunities and needs very much in evidence frequently proposed by industry. Unfortunately, our response to these opportunities has been less than satisfactory so far. Without an obvious institutional home for funds and scant analytical resources, the decision process has been ad hoc and highly politicized.

SEMATECH I believe shows this and the debate about superconductivity and high-definition television seems to be proceeding in somewhat similar fashion.

If, on the contrary, ATP were operationalized with a budget and were able to analyze and perhaps accept responsibility for large initiatives, this would go far toward improving the decision process.

I should emphasize though that I do sympathize with the legislative view of ATP's general purpose. That is, a preponderance of relatively short-term, small-scale funding and that the large-scale programs are more atypical.

The situation today is very different inside the government from what it was in 1980. Of paramount importance is the change in DOD posture toward civilian technology. Not only does the view change inside the DOD, but it seems to me that certain Congressional directives like SEMATECH coupled with the overall pattern of funding have assigned de facto leadership in this area, at least in civilian technology to defense.

Value judgments by DOD aside, it seems hard to argue that if support for civilian technology is desirable there should not also be a viably funded civilian agency.

I am also persuaded on the hopeful side that the institutional structures in the civilian side of government are much better crafted than any of the historical antecedents or proposals. ATP is a relatively simple, straightforward mechanism which is yet endowed with considerable flexibility to respond opportunistically to promising situations that arise.

I think this is good. When an agency looks to the future, it can't plan its investments with precision, and really shouldn't attempt to.

Were ATP housed in the Commerce Department as that agency was five years ago, I wouldn't be so sanguine, but today ATP's parent organization, NIST, is oriented, or should be, toward a clear commitment to serving this nation in the larger umbrella. The Under-Secretary of Core Technology can provide the needed coordination and, hopefully, clout. Plus, the timing is right. The thinking is good. Receptivity appears to be high and, again, the short words: Let's get on with it.

Thank you.

[The prepared statement of Mr. Heaton follows:]

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STATEMENT of GEORGE R. HEATON, JR.*

before the

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

HEARINGS ON

ADVANCED TECHNOLOGY PROGRAM

of the

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

March 8, 1989

Mr. Chairman and members of the Committee, it is indeed a pleasure to be here today to discuss this promising new initiative in our government, the Advanced Technology Program (ATP) of the Commerce Department's National Institute of Standards and Technology. On receiving the Committee's invitation, my first reaction was a feeling of some pride and gratification at the opportunity to help implement an objective that has eluded the country for some time: a civilian technology policy. But on giving the invitation a second thought, I began to worry. Since everyone here today has undoubtedly suffered through the long-windedness that plagues lawyers and professors, my two professions, you can certainly imagine the chagrin -- or should I say downright agony -- with which one of us would approach a request to confine his remarks to five-minutes!

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* Attorney (Massachusetts); Lecturer, Sloan School of Management, Massachusetts Institute of Technology; Adjunct Associate Professor, Worcester Polytechnic Institute

Thinking further and more seriously, I have come to the conclusion that today's message is remarkably simple, and it could, if necessary, be compressed to five small words: "LET'S GET ON WITH IT."

What, more precisely, does this imply? In this brief statement -- expanded in written form for the record -- I would like to comment in turn on what the Congress has accomplished in its delegation of authority to the ATP, how this authority might be further focused by the agency, the operational tactics the ATP should use, and the need for funding support.

Since the early 1960s, the United States has been flirting with the idea of establishing an explicit national civilian technology policy. The process began hopefully with the creation of a spokesperson, the Assistant Secretary of Commerce for Science and Technology, and a number of new programs came under consideration. Three main assumptions underlay these initiatives: first, that technology, long recognized as critical to our national security, would also increasingly form the foundation of our economic future; second, that the U.S. position in the international technical environment had begun to change; and third, that government and industry had a mutual interest in working to ensure future economic prosperity. But these ideas were slow to take root. Specific programs garnered insufficient support in the Congress or the country as a whole (Civilian Industrial Technology,

the SST, and State Technical Services are some examples), and the institutional base for leadership in the Executive eroded over time.

By the early 1980s, when the relationship between technology and international competitiveness had become universally recognized, and the need for government-industry partnerships widely appreciated, the country nevertheless heard a recurring complaint: we had no civilian technology policy. As recently as last year, some time after the Congress had in fact crafted the substance of a technology policy in the Stevenson-Wydler Act, the National Cooperative Research Act, the Federal Technology Transfer Act, and other legislation, it still seemed germane to complain that there was no locus for our policy, no institutional home. And even today, after major organizational change in the Department of Commerce brought about by last summer's Trade and Competitiveness Act, there are some who suggest that we suffer from lack of a coherent policy.

My reaction is just the opposite. With the creation of NIST, its Advanced Technology Program, and the Under Secretary for Technology, the establishment of legal authority for a national civilian technology policy is complete. Moreover, the limits of that authority are extensive and flexible enough to permit virtually any programmatic initiative. The structures in place in the U.S. now compare favorably with those in any of our major trading partners, as I shall discuss below. In my view, there are

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no limiting defects in concept: Congress has given the Nation a clear direction and appropriate institutional structures to do the job.

What remains? Obviously, the tools, the perseverance, and the vision to get on with it. Congress must, if it is serious about what it intends to accomplish, furnish the necessary increment of resources. Beyond this, ATP must itself define the focus of its activity and establish a style of operation consistent with its mandate.

One place to look for guidance is to some of the structures other countries have designed to accomplish similar objectives. To do this, I have prepared the attached chart surveying programs in Japan, France, and Germany, as well as DARPA in the U.S., according to a variety of criteria that may be useful in further defining ATP's mission. The information is based not only on published sources but also on my own research as a visiting professor in Japan and Europe. The bottom line I derive from this analysis is that ATP has a unique niche and can define itself so as to improve on the existing prototypes.

In the aggregate, the trend from abroad is quite clear, and well-known. Each of these countries possesses a strong effort at the national level in support of civilian technology. Programs of this nature are typically integrated with other objectives, often in combination with economic development, support for science, or education. In the minds of public officials, these structures form

a critical aspect of the governmental fabric, and among industrial managers, they comprise an accepted, but clearly subsidiary, element of firms' technology strategy. While explicit support for civilian technology has assumed as higher profile abroad than in the U.S., people in other countries often see our situation in a somewhat different light than we might. In their view, lack of explicit U.S. policy toward civilian technology may be more than overcome by a close connection between the defense and industrial establishments. Moreover, the American ability, supported by a variety of policies, to spawn entrepreneurial undertakings and small firms is universally envied.

Among the programs surveyed, the German Ministry for Research and Technology (BMFT) is largest in size and scope. A cabinet-level department, BMFT is both the coordinator of the nation's technical enterprise as well as an umbrella for many specific programs to support scientific research and industrial technology. The element most analogous to the ATP is a program of direct R&D grants to industry. These grants are given in response to individual company proposals, selected principally through peer review, with some attempt to target particular technical areas. Although a well-accepted means of industrial subsidy, the BMFT program is sometimes criticized for its close connection to a relatively small number of large firms.

The Agency for Research Valorization (ANVAR) in France is a quasi-independent public venture capital organization, whose purpose is to translate research results into commercial products

and processes. Although consistent with the generally activist French orientation toward the direction of technology development, and undoubtedly necessary in a situation where venture capital has been scarce, ANVAR exemplifies a mixed record of "picking winners" in the commercial marketplace.

In Japan, the Key Technologies Center (KeyTEC) was founded in 1986 as a unique, off-budget, Diet-chartered corporation funded with monies garnered by MITI and the Ministry of Posts and Telecommunications when a number of government monopolies were privatized. Like ANVAR, KeyTEC is intended to fill a gap in the venture capital markets. Its focus, however, is on funding long-term basic research that may lead, within a decade or so, to commercial applications. KeyTEC also requires that its clients cooperate to form new ventures. While it is too early to judge success, KeyTEC illustrates the major departures from past practice that have begun to surface throughout Japanese technology policy.

In contrast, the Agency for Industrial Science and Technology (AIST) represents the traditional focus of MITI's technology policy activities. With a general mission to support industrial technology, AIST has developed a highly consultative style in which new initiatives tend to be conceptualized in parallel in government and industry. Historically, AIST's principal policy instrument has been funding for industrial consortia to undertake generic, pre-commercial research broadly relevant to an industry's needs. Early on, in the 1960s and early seventies, the program's major objective was to help diffuse known technology so as to catch-up

with other countries, but before 1980 this had given way to more focused and larger-scale programs in key technical areas such as biotechnology, new materials, and superconductivity. Since AIST funding is typically modest for most projects, and much below industrial levels, its technical impact should not be overrated. Nevertheless, the system of cooperation and information flow -- among firms and between the public and private sectors -- has undoubtedly been of great benefit. Today, however, the change in Japan's international position and the imperative it recognizes of fostering basic innovation have caused many critics to call for an overhaul of this traditional "committee system" for industrial research. Programs such as KeyTEC, mentioned above, have been the result.

In the U.S. context, few dispute the technical successes credited to DARPA since its creation in the late 1950s. Although DARPA is often compared to MITI, the analogy does not really hold. DARPA's initiatives have typically been larger than MITI's, more driven by a technical vision and less by consensus, much less bureaucratic, and, of course, conceived in support of a defense mission that did not apply in Japan.

In considering what this comparison means for ATP, I would suggest that while it can profit from the lessons, both negative and positive, inherent in the above models, it is already cast in a uniquely appropriate mold that need not be essentially changed. Given the situation in which Congress has placed it, a programmatic

unit of NIST, ATP was not intended to play a coordinating role for civilian technology policy. It has a clear, limited mission -- direct support for generic technology of great economic potential -- and should "stick to its knitting." The situation in NIST, however, should not be seen as a limiting factor. On the contrary, it presents ATP with an opportunity, unique among the other programs, to draw on a reservoir of technical expertise and thus form partnerships with industry that go far beyond merely financial arrangements. ATP is also directed to include various actors in its partnerships -- labor, academe, small firms -- that have frequently been omitted from analogous undertakings abroad. The legislative direction also included a clear bias toward small-scale, short-term undertakings, as expressed in a justification requirement when funding exceeds $2 million and three years' duration. While this seems a sound direction, ATP should not be timid and Congress should not be harsh in considering larger ventures. ATP's mandate to fund cooperative ventures in research is also highly desirable, securely in line with current American policy and the Japanese historical experience. Again, however, I would urge that we not be too doctrinaire. The Japanese, for example, committed though they are to cooperation, have come to believe that cooperative ventures are not a very fast-moving vehicle for research in general, nor are they likely to result in technical breakthoughs. Sometimes, therefore, funding for individual efforts may be appropriate. It may also be appropriate to expand antitrust protection under the National Cooperative Research Act to the development or commercialization ventures that

arise from joint research. Without this, both joint research and commercialization may be artificially constrained.

The particular initiatives ATP takes and the style with with they are pursued will depend in large measure on the character of its personnel and the nature of the communications networks it establishes with industry. Among the programs I have surveyed, the German BMFT stands at one pole in assuming a mostly reactive role, waiting for industrial proposals -- what one might call an "NSF for industry." Both of the Japanese programs present a polar case of a different nature, in which industry clearly dominates technical decision-making. This situation arises because MITI's bureaucracy, known though it is for intelligence, political skill, and consistency, is mostly comprised of career civil servants trained in a generalist, legal tradition. Thus ill-equipped to assume technical program responsibilities, the bureaucracy has generally abdicated this function. American civil service and regulatory tradition, seen for example in DARPA's highly expert staff, tend toward exactly the opposite approach, which prompts more-than-occasional industry grumbling about "micro-management" and agendas "dictated" by the bureaucracy.

What seems appropriate for ATP is a middle ground. The level of technical expertise must of course be high, but the agenda must, above all, be responsive to industry needs. One mechanism that will help ensure this is the Visiting Committee on Advanced Technology, but in addition, an active program of personnel

exchange from industry should be instituted. This would provide continual infusions of new ideas, an industry viewpoint, as well as needed resources.

Communications channels to the industrial and academic communities need to be developed through a variety of means that go beyond the Visiting Committee. The experience emphasizes personal and information linkages, and hence a strong tendency toward consensus between the public and private sectors, more than we do. In Japan, for example, the advisory committees for MITI projects, programs, subagencies, ministries, and interministerial functions pyramid into an enormously complicated, time-consuming and inefficient -- but in the end highly effective -- network linking business and industry. Symposia or industrial expositions with joint public-private backing are frequent, and the placement of bureaucrats into industry trade associations is a routine career move at retirement time. In part, these close associations are the natural result of long association between industry and government in a common enterprise. Not having that long association in this country, we need to accelerate things deliberately. In doing so, however, care must be taken not to compromise the arm's length traditions we have crafted over the years: for example, the New Year's ritual in which businessmen do obeisance and give gifts to public officials in Kasumigaseki certainly does not bear repeating in Washington!

The creation of NIST and the ATP, positive signs though they are, come at the end of a somewhat frustrating line of promising

Congressional policy initiatives that have received inadequate implementation. One is most cautioned, for example, by the history of the Stevenson-Wydler Innovation Act of 1980, in which the Centers for Industrial Technology were rendered nugatory by lack of funding. In the current budgetary climate, there is a real risk that ATP may suffer a similar fate. And the straightforward argument that a clear, operational mandate made by the Congress should be funded may carry even less weight today than it did in 1980.

There are, however, several major differences between the situation of 1980 and 1989 that should persuade us to take a different, more generous appropriations path. Perhaps most obviously, increased international competition makes the national imperative to commercialize technology more effectively all the more pressing. Second, the industrial perspective has changed radically. Industry appears committed not only to inter-firm cooperation but also to the notion of government participation in a joint enterprise. Clear opportunities and needs are very much in evidence. The approximately 50 research consortia formed under the National Cooperative Research Act, for example, are exactly the type of research joint venture ATP is intended to support. Sumatech is operational, and proposals with merit have come forth in areas like superconductivity and high-definition television. In short, requests from the private sector have arisen and will continue to.

Unfortunately, the country's response to these opportunities has been less than satisfactory so far. Without an obvious institutional home for funds, and scant analytical resources to consider the problem, the decision-process has been ad hoc and highly politicized. Sematech's genesis shows this, and the debate about superconductivity and high-definition television are proceeding in similar fashion. If, on the contrary, we had an operational ATP, able to analyze and, perhaps, accept responsibility for such initiatives, this would go far toward improving the way the country makes such decisions. I should emphasize, however, that I sympathize with the legislative view of ATP's general purposes -- i.e., a preponderance of relatively short-term, small-scale funding -- and see large-scale programs as an atypical activity.

The situation inside the government is different as well. Of paramount importance, DOD posture toward civilian technology has changed greatly. A fascinating intellectual debate is engaged about the definition of national security, to what extent it rests on basic civilian technologies in manufacturing, materials, computers, etc. Meanwhile, however, particular Congressional directives, like Sematech, coupled with overall pattern of research funding, have assigned de facto leadership for this area to Defense. Value-judgments about specific DOD programs aside, it seems hard to argue that if support for civilian technology is desirable, there should not also be a viably funded civilian agency to accomplish it.

Lastly, I am persuaded that the institutional structures on the civilian side of government to pursue civilian technology initiatives are much better crafted than any of their historical antecedents. ATP is a relatively simple, straightforward programmatic mechanism endowed with considerable flexibility to respond, opportunistically, to whatever promising situations arise. This is good: an agency looking always to the future cannot plan its investments with precision and should not attempt to do so. The general focus on industry-initiated, jointly funded, small-scale research consortia presents an entirely appropriate role for government: support for activities of wide benefit when the private sector lacks the means to do so fully. Were ATP housed in the Commerce Department as it was five years ago, I would not be sanguine. Today, however, ATP's parent organization, NIST, is oriented toward a clear commitment to serve industry, and its larger umbrella, the Under Secretary for Technology, can provide coordination and, hopefully, clout. Thus, the timing is right, the thinking is good, and the receptivity high. LET'S GET ON WITH IT.

SUPPORT FOR INDUSTRIAL TECHNOLOGY: POLICY MODELS

| | BMFT (Ger.) | ANVAR (Fr.) | KeyTEC (Jap.) | AIST (Jap.) | DARPA (U.S.) |
|---|---|---|---|---|---|
| SITUATION | Ministry | Quasi-indep. | MITI, MPT, private funds Diet-charter corp. | Sub-unit of MITI | DOD program |
| MISSION | Support sci. research & ind. tech. | Commercialize research results | Promote commercial applic. long-term bas. res. by new entities | General support for ind. tech. | Tech. to support defense |
| INITIATIVE | Industry proposals | Ind. proposal gov't plan | Proposals from joint ventures | Parallel gov't, ind. | Tech. experts |
| INSTRUMENT | R&D grants to industry | Venture capital | Venture capital | Funds for research consortia | Funds for univ., ind. research |
| FOCUS | Company-specific | Commercial | Innovation, new orgs. | Diffusion of tech., targeted large progs. | Tech. infrastruct. |
| STYLE | Bureaucrat. peer review | Financial orientation | Not yet well defined | Slow, bureaucrat., consultative | Flexible |
| EVALUATION | Well-estab., SOP for large cos. | Mixed | Too early; Major depart. from past | Success in catch-up; less suited to future needs | Highly successful |

Mr. WALGREN. Thank you very much, Mr. Heaton.

Then we'll turn to Dr. Flamm. Welcome to the Committee, Dr. Flamm.

## STATEMENT OF DR. KENNETH FLAMM, THE BROOKINGS INSTITUTION

Dr. FLAMM. Thank you, Mr. Chairman, and good morning.

I, too, am going to follow the hallowed tradition of departing from my prepared remarks to sort of briefly summarize what I think the relevant points are.

I am going to take a different pass, I think, at the issues at stake here than my colleagues have, and I'm going to briefly talk a little bit about what I think the need is for this type of program, and then how NIST perhaps can address that need.

It's important to start out by recognizing that there are fundamental reasons why the political consensus and industrial consensus that George just referred to has changed.

Why isn't there substantially greater support for this kind of program today?

The system of public investments in technology that the United States, or had until recently, was put into place during and after World War II and addressed a very specific set of requirements that came out of that conflict.

The objective was national defense and the commercial spillovers resulted in the technology base that generated much of today's high-technology industry was a virtually unforeseen outcome of those initial investments.

Today, the world has changed. The system that we put into place back in 1940 and 1950 is really no longer adequate for the needs of today's economy. And I think there are fundamentally two reasons for that, both of which have been alluded to.

Firstly, we clearly have competitors—real live competitors—in a way that we never did in the past. During and after World War II, obviously, Europe and Japan were preoccupied with rebuilding their economies and did not become significant competitors as technological peers and equals until relatively recently.

Obviously, today, with technological peers nipping at the heels of American industry, effectiveness, efficiency and speed are critical for an effective technology program. And our programs historically were not designed for that purpose and with those objectives in mind.

Second, I think investments in the military technology base, which historically we relied upon for our commercial technology base as well, are less fruitful in terms of spill-over and results relevant to the commercial economy. And I think there are basic reasons why.

I don't really have the time to explore this in great detail. I've appended a chapter from a recent Brookings publication which contains an extensive discussion of this topic, which I invite you to peruse.

But, basically, I would argue firstly the technologies in which the military makes most of its investments are much more mature today than they were back in 1950.

Consequently, one would normally expect less spill-over.

Secondly, there's been a shift away from research and toward applications, specific requirements, missions and so-called technology niches in the DoD spending program, in relative terms.

I think that's clear if you look at budget and, again, a useful diagram is appended in the chapter I referred to. So the question is: What do we need?

And I think there really is no theory. For starters, there is no economic theory that gives you a precise prescription on how to invest in the commercial technology base. There are good, sound economic reasons, which I won't go into at the moment, which provided arguments for why you go about investing it. But exactly how you structure that investment is a black box that really isn't addressed very well by economic theory.

And for that matter, there are no practical guidelines which would provide black and white answers on these questions.

I think the way to look at the issue is as a series of small scale experiments perhaps in directing resources toward commercial development of technology that we ought to be carrying out.

If you look at the history of Japanese investments and technology, one of the lessons that emerges from a historical review of Japanese programs is that their very flexible approach has been experimental in nature. They have attempted new experiments when they worked on a small scale. They've been expanded and drawn out on to a larger scale.

And I think that's not a bad principle for thinking about how we go about reorienting our system of public investments in technology.

I think there are certain principles that ought to be heeded and perhaps experimented with as we go forward with this enterprise.

First, I think it's clear that the time is now ripe for explicit recognition of the government role in investing in the pre-commercial technology base.

We've danced around, as it was referred to earlier—for years—around this particular topic. And the typical response to a perceived technology need is to find some way to squeeze it into a national defense rationale.

Unfortunately, this has the unforeseen and unwanted side-effect of distorting the objectives in some cases and basically shifting priorities away from commercially relevant markets.

So I think that's one principle that it's high time that we recognized government has a significant role in investing in the pre-commercial technology base in this country.

Second, I think the emphasis on research consortia that we've been moving toward is a useful experiment that ought to be encouraged.

Furthermore, I think for a variety of reasons we ought to be thinking about a separate institution that basically serves as what I would call a protector of middle ground research. Very basic research already has its protector, its insulator from budget battles and spokesperson and that of course is the National Science Foundation.

We ought to be thinking about some institutional protector for middle ground research. That is, research that's more applied to

commercial technology than basic research, but stops well short of commercial exploitation and commercial development of technology.

Mr. BEUCHNER. Mr. Chairman, could I interrupt?

Could you give some examples of that middle research for lay people that are kind of hanging on the edges there?

Dr. FLAMM. Sure. What I mean, middle ground research, when you look at how, for example, basic research gets defined, fundamental science is undertaken in principle with no commercial purpose in mind. It's pure science.

So if, for example, basic physical principles, obviously basic research, if you're trying to develop a device using a new principle, a new kind of device, a quantum effect based transistor or something, specifically when you're undertaking the research with the idea in mind that some day this is going to be used in commercial technology and that's why you're undertaking the research, then, technically, that would not be considered basic research. That would be something you undertake with an application in mind.

That's neither fish nor fowl. It's neither quite basic research, it's not really product development. It's applied research. But I would call it middle ground research if it is drawing on basic physical principles.

You're getting into a very gray area here, unfortunately. When people talk about R&D, there are no firm black and white lines between the D and the R and the basic. But there is the general notion that there is something in the middle between very basic research and between very specific development. And that's what I'm talking about.

Mr. BEUCHNER. OK.

Dr. FLAMM. Pre-commercial. And then, of course, the third principle that I'm talking about is that industry ought to have a substantial impact on the R&D programs we're talking about. It should not be top/down government in its wisdom, sort of drawing up basic principles for the program and sort of throwing them out and saying:

Industry, here, go do your thing.

I'm talking about a system where industry has a substantial input into the agenda. What research topics and, furthermore, the industry puts its own money presumably into the same consortium, for example, and, therefore, has an incentive to sharpen its focus.

The kind of role I'm talking about is a role in which government serves as a facilitator and information-gatherer, a scanner on the international horizon and a helper with industry, where it perhaps would provide the information industry in a top/down role, but it would very much have a bottom/up kind of structure in place as far as getting proposals for research and seeking ideas from industry for that agenda.

I think NIST is in a position to play such a role through programs like the advanced technology program. But I think it has some historical baggage, so to speak, that it ought to be reconsidering.

First of all, the organizational structure I'm talking about has to focus specifically on this mission and not be incorporated into a

grab bag of other programs serving a wide variety of needs and missions.

It ought to have its own agenda and it ought to have a certain amount of independence and autonomy. If NIST can be set up to function in this way, it obviously is in place and ready to go with this sort of program.

But it shouldn't be a grab bag for various tidbits of technology that really don't have a coherent focus. I do believe that there ought to be a focused agency in place for implementing this kind of agenda and I think NIST potentially, if given the proper degree of independence, over time can play such a role.

Second, in such a program, in such an agency, there ought to be a shift from internally-preformed R&D as in a typical government laboratory to leadership of externally-performed projects and consortia.

That's not to say that internal R&D is ruled out, but it really ought to be auxiliary. It ought to be supporting a program which is explicitly focused on a leadership role on external products for the industry.

Now, can NIST be transformed? Or, can this program serve as a spearhead for such a program?

I hope so. Obviously, a lot of things are required, including consensus with the administration on the change in objectives. Funding and some perhaps reorganization within NIST.

I think it's important that these objectives be given their own organization and I would look upon ATP and the subsequent evolution and development as an opportunity to create such a structure.

Thank you very much.

[The prepared statement, plus additional material, of Dr. Flamm follows:]

Insert T.3

Testimony of Dr. Kenneth Flamm

before the

House Committee on Science, Space, and Technology

March 8, 1989

Good morning. I thank you for the invitation to testify on the appropriation for the National Institute of Standards and Technology (NIST), an organization which I believe can play an important role in the restructuring of America's public investments in its commercial technology base. While I do not have the time to repeat the details of fairly lengthy and complex arguments I have made elsewhere,[1] I will highlight some essential points.

In the United States, public policies to support investment in advanced technology have historically been primarily preoccupied with national security. World War II was the occasion for a qualitative change in the levels and organization of public resources invested in research and development. The war involved an unprecedented mobilization of American scientists and engineers in a vast military R&D project. Before the war the government had paid for 15 to 20 percent of U.S. research; after the war it funded more than half of a vastly expanded

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1. The relevant chapters are appended to this testimony. See Kenneth Flamm, Targeting the Computer: Government Support and International Competition (Washington: Brookings Institution, 1987), chapter 6; (with Thomas L. McNaugher, "Rationalizing Technology Investments," in John Steinbruner, ed., Restructuring American Foreign Policy, (Washington: Brookings Institution, 1988), chapter 5.

national effort. Out of these continuing investments came the technology base for much of our modern high tech industry--in areas like electronics, computers, telecommunications, instruments, and aerospace.

However, these industries were largely an unforeseen outcome of investments motivated by military objectives. Since that time, as military technologies have matured, the demands of national security investment have diverged from those of commercial applications, while the broad economic implications of the new technology have become as important as achieving purely military objectives.

And today we live in a different world. Industrial societies that were still recovering from the damage of World War II when the U.S. acquired its general technical advantage have learned to adopt our accomplishments. U.S. businessmen now increasingly complain that American innovations in basic science and technology are being commercialized abroad with little of the profit flowing back into the pockets of Americans whose tax dollars financed much of the initial investment. These industrial rivals, moreover, have come to undertake their own technical investments in amounts comparable to the United States', and since they direct a higher proportion of it to commercial purposes, their investments now exceed our own in that area. Meanwhile, defense research and development seems less effective than it once was in generating commercial benefits and is itself more in need of the discipline and innovative impulses that well-developed markets provide.

Changing circumstances call for changing policies. A new world of peers and competitors means that, more than ever before, public investments in technologies expected to benefit either the U.S.

industrial base or the defense effort must be effective and efficient. And the increasing maturity of much U.S. military technology, and tightening budgets, means military R&D can no longer be expected to build the commercial technology base. Where military investment is in frontier technologies, expanding the outer envelope of technological advance, defense investments can help create technologies that will ultimately benefit industry. But the existence of nimble and able foreign competitors means that speed and effectiveness are essential in reaping commercial returns, and the defense establishment is simply not organized for rapid and efficient application. The core defense technologies--ships, aircraft, and tracked vehicles--are more mature, increasingly specialized, and inherently remote from commercial markets. The expense of each item and the limited scale of production mean that the relationship between the evolution of design and the ultimate product must be very different. For both economic and security reasons the United States must reconsider the way it organizes investments in technical innovation.

While the details are still uncertain and disputed, the guiding principles of necessary reforms seem clear enough. Public support for developing the commercial technology base ought to be defined and justified on its own terms. It should not depend on a concocted claim that it is needed to maintain national security, an appeal designed to tap the deep pockets of the defense establishment. Conversely, military requirements for technology ought to be defended in military terms, and not draped with claims of commercial spillovers when the logic of military necessity seems weak. Improving the effectiveness of investment

in commercial R&D means creating an agenda responsive to the technological needs of industry. It also means experimenting with new forms of organization designed to increase cooperation within industry and between industry and academic research institutions.

## The Commercial Technology Base as a Legitimate Interest of Government

The very first thing we must do is explicitly recognize that supporting, facilitating, and organizing investments in pre-commercial technology--basic science and middle-ground research--is an important function of government in the high technology economy of the coming decades. The debate ought to be how to best organize this investment to build the best, most advanced industrial economy in the world. We ought not be burdened by the need to devise elaborate ruses and strategems so that other missions of government can be teased and stretched to have some incidental effect on what is clearly a major task for our changing economy.

## New Institutions

The National Institute of Standards and Technology can play a major role in the rationalization of public technology investments that I believe is needed. At the very least, it can provide an institutional home for a flexible program designed to facilitate the formation and funding of cooperative, "middle-ground" research programs involving industry and universities. These programs might include experiments like

Sematech and the embryonic national research initiative in high temperature superconductors.

A major problem with funneling support for pre-commercial middle ground research through existing institutions is the effects of "Bush's Law." Dr. Vannevar Bush, czar over much of the unprecedented wartime R&D effort in the United States, served as head of the Office of Scientific Research and Development. Bush drew on an extensive background as a practicing engineer and scientist, professor and dean of engineering at the Massachusetts Institute of Technology, consultant to industry and government, and a key participant in the flowering of modern industrial research within corporate America in the 1930s. Though he was a firm believer in the value of markets in directing resources, Bush was an equally stubborn believer that private efforts alone could not produce the research base required by the new industrial technology. When basic research competed for scarce research dollars in a corporation, Bush argued, it would inevitably be cut back in favor of product and process development. Bush's law paralleled the later argument (which was not to be articulated in its modern economic form until 1959) that a private company could less easily capture ("appropriate") the benefits of basic research effort than it could the benefits of product development.

To protect basic research from open competition with development efforts, Bush proposed creating a national research foundation to insulate investments in basic research from the pressures of profitability. Today's National Science Foundation, with its elaborate systems of peer review oriented toward pure intellectual merit and away

from economic or commercial return, is the modern legacy of Bush's vision.

Although Bush did not make the point, his law may apply to much technology spending in the public sector as well. In such "mission" agencies as Defense or Energy or NASA, stringent budgets have typically meant cutting back on longer-term, more speculative research in favor of delivering the functioning systems that commanders, or department heads, or mission specialists are clamoring for. The projects most distant from clear or immediate missions are sacrificed--and this too means development is favored over research.[2]

Administered through so-called "mission" Federal agencies, support for "middle-ground" research too would inevitably come into competition with more applied, mission-related projects, and presumably suffer in battle over scarce R&D dollars within the agency. One might argue for adding these objectives to the National Science Foundation's plate, but such a shift toward long-term economic and commercial relevancy criteria

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2. "Applied research and development differs in several important respects from pure science. Since the objective can often be definitely mapped out beforehand, the work lends itself to organized effort. If successful, the results of applied research are of a definitely practical or commercial value. The very heavy expenses of such work are, therefore undertaken by private organizations only in the hope of ultimately recovering the funds invested. . . . The distinction between applied and pure research is not a hard and fast one, and industrial scientists may tackle specific problems from broad fundamental viewpoints. But it is important to emphasize that there is a perverse law governing research: under the pressure for immediate results, and unless deliberate policies are set up to guard against this, applied research invariably drives out pure." See Vannevar Bush, Science: The Endless Frontier, a Report to the President on a Program for Postwar Scientific Research (GPO, 1945), p. 77.

would conflict with the NSF's historical charter of divorcing basic research funding from commercial tests of any sort.

What is needed is a separate institution, with its own new and important missions to protect support for economically significant middle-ground R&D projects from the ravages of Bush's Law. If the budget for these sorts of projects is to be altered, let it be an explicit Congressional or Executive mandate, not the product of internal budget wars within agencies with only a peripheral interest in the health of the commercial technology base. The NIST could well provide a cogenial home for federal investments in the industrial technology base if it were granted the required autonomy and independence within the Commerce Department. Alternatively, a significant part of the organization could be removed from the Commerce Department and joined with a revamped Office of Science and Technology Policy reporting directly to the President. Such a skilled, reasonably small and agile organization with some internal technical capacity, might be a most useful experiment to undertake in order to revitalize our public investements in commercially relevant technology.

## Industrial Relevance on the Agenda

Industrialists are certainly in closer contact with the market than bureaucrats, and may have valuable insights into what technologies are potentially of greatest commercial importance. It therefore seems important to give industry a significant role in setting the agenda on support for research intended to strengthen the commercial technology

base. Rather than the Pentagon--or NIST--drawing up plans and issuing directives, a better model might be a government institution serving as a contact point, facilitator, collector of information and scanner on the world horizon, to which industry comes with a proposal, distributing reports and proposals to industry for comment and possible expressions of private sector interest.

The key point is that since industry is in the best position to judge commercial relevance, industry ought to play a major role in formation of the agenda. Such projects should always be designed to benefit the technology base of an industry, not an individual firm or group of firms.

To conclude, the United States in the 1980s faces the maturation of its military technology and international economic competition with technological peers. The United States should move to help firms earn returns on technological investments. This in turn means it must recognize the government's role in maintaining the industrial technology base. New policies must be designed to help American firms commercialize products that draw on American advances in science and technology. Effectiveness and efficiency must become hallmarks of the R&D investments intended to benefit the economy of tomorrow. The NIST can become a major contributor to this transformation of our policy.

KENNETH FLAMM

# Targeting the Computer

## *Government Support and International Competition*

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THE BROOKINGS INSTITUTION
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slipped, prompting renewed American investments in new component technologies. Wafer-scale integration, exotic (nonsilicon) materials, rapid turn-around "silicon foundries" and associated design tools, and the very high speed integrated circuit (VHSIC) program are all areas in which large new public investments are being made with an eye leveled on the foreign competition.

CHAPTER SIX

# National Technology Policy: Past, Present, and Future

THE DEVELOPMENT of the electronic digital computer is a useful case study in the development of modern high-technology industry. The computer was born during the second world war, a product of powerful and pervasive institutional change that reshaped the American economy. It ranks among the most research-intensive goods, and development of computer technology requires complex interactions among the interests of the state, private business, and the public welfare. Determining the contours of investment in technology is one of the most important economic choices that societies make.

The computer emerged in an arena that was international in scope right from the start, where it was impossible to separate competition at home from rivalry abroad. Firmly connected to the United States' national security, economic and military, the computer was guaranteed a special status by the willingness of the military services to push its development when civil authorities seemed to lack the interest, the will, or the resources.

## The Past: A Summary

At first the economic significance of computers went unnoticed; military need, not the economic imagination, propelled the technology forward. A few far-sighted visionaries saw the computer's commercial potential, but had it not been for the military's interest in powerful information processing capacity, its development would certainly have been delayed by years, perhaps even decades.

Throughout the 1950s the links between commercial and military

technology remained strong. Many of the American computers built were government-financed machines adapted to the commercial marketplace. The differences between the United States and the other industrialized countries during this decade are particularly striking. The scale and scope of funding for computer development in the United States dwarfed efforts abroad. The Air Force's SAGE project alone accounted for billions of dollars in development funds, compared with tens of millions, perhaps, invested abroad. Great Britain, initially a credible technological rival to America in computers, slipped further and further behind. Close to one hundred firms entered the computer business in the United States in the 1950s compared with fewer than ten in England. When business demand for computers exploded in the early 1960s, the scientifically oriented machines built by British firms were overrun by business-oriented American computers, and the long, sad decline of the British computer industry quickened. France, Japan, and West Germany trailed far behind the United States in the infancy of computer development. They each had a few small, primitive machines not far removed from experimental research prototypes. Other European countries dropped out of the competition altogether, and their researchers staffed the first multinational laboratories, the early outposts of an increasingly internationalized industry.

The American market decisively shifted away from government customers toward commercial business users in the late 1950s. The rapid growth of the market was largely driven by technological advance: continuous, accelerated declines in the cost of computing power opened up new applications. Use of information processing machines had become economic. But the technological base from which these cost declines flowed, including electronic components, continued to benefit from a steady diet of government funding.

As the market for business computers opened wide in the early 1960s the technological lead of U.S. firms translated into solid profits. Dependence on the United States for what was becoming an essential capital good increased. U.S. export controls on shipments of high-performance computers to France dramatized that the so-called strategic argument for having an autonomous technology base was more than a thinly veiled appeal for protection of an infant industry. Interruption of the supply of products embodying state-of-the-art technology could have potentially crippling effects, not just on military preparedness, but also on the increasing number of user industries.



France, then West Germany, and then Great Britain embarked on crash programs to build up their national base in computer technology. The basic formula was generous R&D funding, government procurement preferences, and protection from foreign imports. The latter policy, as it turned out, served mainly to increase U.S. computer firms' European investments.

Analysts at the time emphasized the advantages of market size in reducing the per unit development costs for new products. Consolidating all computer production into one favored "national champion" was a popular solution. The hope was that by creating a smaller, national, "scale model" of IBM, the European markets dominated by IBM would be recaptured. It was an inward looking strategy that overlooked the economic logic for tapping into global markets in technology-intensive goods. And it was a losing strategy in Europe for precisely the same reasons that facing off with IBM in established markets was a losing strategy in the United States. Worse yet, no support was given to new entrants in a position to go after new markets in the manner that was to prove successful in the United States.

Of the European countries only West Germany reconsidered its initial strategy. This change of heart came after Nixdorf, with absolutely no help from the state, bested the performance of the chosen national champion by pioneering the European minicomputer market. This more diverse style of support has been relatively effective. Today the German computer industry is generally regarded as the strongest in Europe. Although computer research in Britain is quite highly regarded, its commercial industry remains weak. And France's two decades of protective nurture for a single national champion has had little apparent impact on its ability to prevail against its rivals in open competition.

Japan took a rather different tack. By carefully controlling access to the Japanese market, Japan's Ministry of Trade and Industry (MITI) attempted to induce U.S. computer producers to transfer computer technology to Japanese manufacturers. At the same time it promoted research and development within Japanese industry. The development of the underlying technological infrastructure took place under the technical leadership of Nippon Telephone and Telegraph (NTT) and MITI's Electrotechnical Laboratory. In the early 1970s this infrastructure was seriously shaken when many of the American firms with arranged marriages to Japanese producers dropped out of the battle for computer markets.

A new focus on support for national R&D efforts, with heavy reliance on MITI-brokered cooperative industrial research, was begun. In entirely unforeseen ways this strategy proved effective. The key development in international competition in computers in recent years has been the steady and rapid advance of Japanese computer technology. Japan now has achieved parity with the United States in many commercial products. Japan's announcement in 1981 that it intended to become a leader in frontier research areas (the oft-mentioned Fifth Generation project) prompted considerable reaction around the world.

The bold technical goals of this ambitious project reflect a shrewd assessment of economic realities. After all, if advanced parallel computers or new types of software products render existing technology truly obsolete, whole new methods of programming will be needed. Then the existing stock of software—the basis for much of IBM's advantage in global markets—will gradually be replaced. A new generation of fundamentally different types of advanced products will open up a vast new market—a market where past hegemony will provide minimal advantage.

### *The Role of Government*

The role of government in stimulating the development of computer technology in the United States, unlike Europe and Japan, became considerably less visible during the 1960s. As the commercial market mushroomed, the general influence of government sales and R&D funding steadily declined. Nevertheless, the most sophisticated and most advanced hardware and applications continued to be funded by federal users.

The military services have always provided the bulk of government funding for U.S. computer research. For a while, the military share of computer research support declined, but the host of new military programs to sponsor computer technology announced in the early 1980s, in apparent reaction to the eroding American lead in commercial markets, suggests that this trend has been reversed. Civilian funding for computer research, particularly for applied research and engineering projects, has also increased dramatically in the United States in the last several years.

Military dominance of U.S. computer research contrasts sharply with the situation in Europe and Japan. The sources of funding have primarily been commercial even in France, where access to supercomputers



needed for military research was a catalyst to the program of support for computer technology begun in the mid-1960s. In West Germany and Japan, ministries charged with supervision of industrial development and scientific research, not the military, have been the big spenders on computer development.

In the United States, spin-offs into the industrial sector have been a major objective of military support for computer technology. The promise of significant "fallout" motivated programs begun by the Defense Advanced Research Projects Agency (DARPA) in the early 1960s as well as its recent grand effort, the strategic computing program. By upgrading the technology that the military can procure from industry, the military, as a computer user, benefits. Needless to say, industry and the commercial computer user also benefit, and the social returns reaped from commercial use (which certainly overwhelm those from military use in sheer numeric terms) have probably far outweighed the gains from reduced cost and increased capabilities of military systems. In fact, technological megaprojects like the SAGE air defense system—expensive white elephants from a strictly military point of view—gave rise to important new commercial technology. They are remembered with pride and affection as great successes rather than as costly and failed attempts at buying a technological national security fix.

Attempts to quantify the extent of government involvement in financing computer research turn some popular myths about "targeting" policies on their heads. While it is true that Japanese authorities heavily subsidized computer development in the 1970s, these efforts have never approached the relative share of all R&D funds supplied by the U.S. government in the 1950s and 1960s. The proportion of computer R&D performed in MITI-organized cooperative computer research projects in the mid-1970s—the peak—was about half of the total, and only one-quarter of all funds were supplied by government. This fraction is just a little more than the share of all distinctly identifiable computer research paid for by the U.S. government in the early 1980s. Moreover, the Japanese government's relative role in financing computer research declined significantly in the late 1970s. Today government directly funds *less* of Japan's industrial computer research and development than is the case in the United States or Europe.

There are other means of supporting a research-intensive industry, and historically they have been important. In Japan during the 1960s and early 1970s, tax measures favored computer producers and users. But

in the mid-1970s policy shifted to favor investment in particular technologies over other, more general subsidies to investment, and tax subsidies shrank in significance. Emphasis was redirected to research and development. Overall, there is little evidence that such tax preferences are a major factor in competitiveness today. (But one unusual, and perhaps irreproducible, feature of Japanese tax policies favoring high technology is the frequency with which incentives have been set, adjusted, and revised.) In Europe policy shifted in the opposite direction, and general subsidies to cover the losses of the ailing British and French national champions increasingly replaced the more targeted support for research and development that was typical of earlier years.

There is also little evidence that the subsidies inherent in the provision of low-cost loans from state-controlled financial institutions have been very important in recent years in Europe (with the possible exception of France's aid to Bull) or Japan. Direct support for research seems to be the targeting weapon of choice, and general subsidy the medicine of need for truly desperate financial ailments.

Procurement preferences by government users have been a powerful instrument of policy in Europe and Japan. By far the highest proportion of government markets has gone to national producers in Japan. European procurement has also favored national firms but to a lesser extent, perhaps in part because the products offered by European producers have not matched those of Japanese manufacturers in quality and breadth.

In the United States federal procurement of foreign hardware has never been much of an issue, presumably because of the superiority of American technology. But now Japanese producers are offering supercomputers that are competitive with American products (with the added fillip of some degree of compatibility with IBM machines).[1] It remains to be seen whether the United States' open procurement policies will continue. None of the new supercomputing centers sponsored by the National Science Foundation (NSF) will use Japanese equipment. The

1. Benchmark tests run on Cray X-MP/2, Fujitsu VP-200, and Hitachi S810/20 supercomputers in 1984 and 1985 showed the Cray and Fujitsu machines roughly comparable in performance for typical workloads from the Los Alamos National Laboratory and the Hitachi machine somewhat slower. See Olaf Lubeck, James Moore, and Raul Mendez, "A Benchmark Comparison of Three Supercomputers: Fujitsu VP-200, Hitachi S810/20, and Cray X-MP/2," *Computer*, vol. 18 (December 1985), pp. 10–24.



moment of truth may yet come when one of the U.S. national laboratories or universities considers buying a Japanese supercomputer.[2]

The structural aspects of Japan's support for research, not just the billions of yen invested, explain its successful record in catching up to the United States in state-of-the-art commercial computer technology. Japan clearly pioneered the concept of joint industrial research. Together and in parallel, industry and government invest in a generic, precompetitive, technology base, which is then further developed into commercial products within individual firms. Such arrangements reduce duplication of the least appropriable elements of investment in technology, which, although critical to further progress, are not particularly rewarding to the company that shoulders their financial burden. Cooperative research also effectively shares the risk in more speculative, long-term research investments. The best testimony to the perceived success of these policies is the extent to which they have recently been imitated in the United States and Europe, in many cases as the result of private initiatives.

Perhaps the most fascinating aspect of these nations' technology policies is the cycle of action and reaction stimulated through competition in the international marketplace. Pushed by the desire to stay competitive with foreign producers, governments have repeatedly altered their policies in reaction to developments abroad. The United States' superiority in a rapidly expanding market pushed Europe and Japan to large-scale intervention in their industries in the mid-1960s.

As a direct consequence of the financial demands of the Vietnam War, the U.S. government's support for computer technology, insulated from international competition by the lead it enjoyed at the time, declined. It was the visible return on Japan's technology investments in the late

2. C. Gordon Bell, the NSF administrator charged with oversight of its supercomputer program, recently noted that it was "NSF's intent to fund the five national centers such that they can all have the leading-edge computers manufactured by our *domestic* industry" (emphasis added). Willie Schatz, "Render unto Caesar," *Datamation*, vol. 33 (March 1, 1987), p. 22. In fact, the heavily discounted sale of an NEC supercomputer to the Houston Area Research Consortium (HARC) in March 1986 provoked a considerable outcry. And the award of a procurement contract to Honeywell, involving the sale of its largest mainframe computer model, sparked some public furor in the fall of 1986. The reason for the episode was that the Honeywell computer was actually manufactured by Japan's NEC Corp. See Richard Gibson, "Honeywell to Sell Pentagon a Computer Designed in Japan; Competitor Cries Foul," *Wall Street Journal*, October 17, 1986; and Karen Gullo and Robert Poe, "Where There's Smoke, There's Fire," *Datamation*, vol. 33 (March 1, 1987), p. 18.

1970s that awakened American industry and government from their complacent slumber. And it was the direct challenge of Japan's Fifth Generation program that provoked a massive new wave of American (and European) R&D investment in the mid-1980s.

Ironically, domination of the international marketplace is in many respects the least significant reason for a society to invest in computer technology. The social rate of return to this investment has been quite high. With rather conservative assumptions, an economic rate of return on the order of 50 to 70 percent is produced for society; more realistic assumptions would push the calculations even higher. Private returns, on the other hand, are considerably lower because of the pressures of competition from other high-tech firms and the relatively short time during which private firms have an exclusive monopoly over the fruits of their R&D investments. The social benefits of R&D investment may last forever, but the private profits produced, while sweet, are short lived.

The bulk of the social return is mainly reaped by domestic consumers in lower prices, and it far outweighs any technological rents derived from domestic and foreign sales. Yet, because foreign sales are a large portion of private revenues (typically 40 to 50 percent for U.S. firms), rents derived from foreign operations are a major source of private return on U.S. investments in computer technology. Without them, marginal projects would not be undertaken, and the pace of technological advance would slow considerably.

### *The Directions of Technical Advance*

The economic rationale for a continuing government role in computer development is closely tied to the degree to which private firms can capture the results of R&D investments. No matter how great its payoff, basic research is more difficult to appropriate privately and therefore less likely to be undertaken by private firms. Private firms also are less likely to undertake radical innovations (as opposed to incremental advances) because much of the uncertainty in moving far beyond existing demand curves can be resolved only by actually developing and marketing a highly innovative good. Prospecting for profitable innovations on the technological frontier yields information about the nature of demand that is as easily grabbed by claim jumpers as by the risk-taking explorer.



Therefore, private firms have a considerable incentive to hold back and not hazard their own capital in removing these uncertainties.

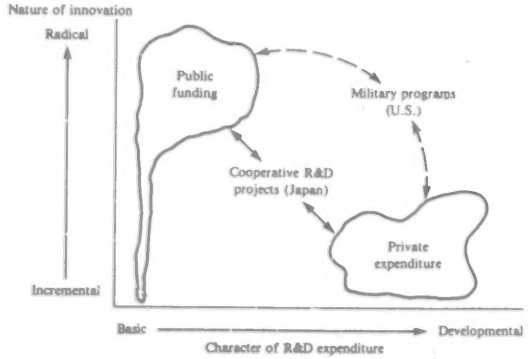
Over time government support has assumed its greatest role in exactly these two areas: the most basic research and the most radically innovative projects. In the very beginning of the computer industry, government dominated all aspects of the technology, from financing development to buying production. But as computers evolved and diverged technologically, government became more important in some aspects of technology development, much less important in others.

The growth of the U.S. market is instructive. Around 1950 the government (defense contractors included) was the only significant customer and funder of research. The technological directions that were being explored were aimed at improving all dimensions of computer performance. Around the mid-1950s small start-up firms began to deliver machines that were smaller and offered lower performance but were much, much cheaper. Their designers took established technologies and invented clever ways to cut cost without proportionate losses in performance. Government users remained the initial customer for many of these machines, but they played little direct role in their design.

In countries with less-developed computer industries, such as Japan and France, the market for smaller machines was the niche into which their early computers fit. Because of the emphasis in this market on clever designs using already developed component technologies, and on settling for lower performance, a recent entrant has some chance of becoming competitive without spending enormous amounts on research and development. U.S. government research support, on the other hand, clustered around the high-performance, large-scale, scientific end of the computer spectrum. Government users began to purchase commercial, business-oriented machines for their ordinary data processing needs, and federal support for research and development was reserved for technologies that pushed the limits of speed and size and therefore favored developments most applicable to the very largest, high-end, scientific machines.

When the commercial market began to really take off in the mid-1950s, government sales became considerably less important to U.S. vendors of small and medium-sized scientific computers and business-oriented machines of all sizes. Government purchases rapidly shifted toward more commercial types of applications. Even before private

Figure 6-1. *Public versus Private Investments in Technology*




business, government had begun to automate and computerize its record-handling and data management functions.[3]

Thus as the U.S. industry matured, the government's role in stimulating research and sales grew quantitatively smaller. Federal research support was concentrated in leading-edge, high-performance machines. However, since the most advanced technology ultimately diffused into the mainstream of commercial computing, the impact of this support was considerably more influential than the numbers might indicate. The results of these efforts were transferred to industry through the publication of research and, more important, through the mobility of engineers. Then and now it is the most advanced, risky, and speculative technologies that benefit the most from government research expenditure.

Figure 6-1 portrays one way of viewing the distribution of potential R&D projects. On one axis, projects are sorted by the mix of R&D effort required, from most basic to most applied and developmental. On the

3. Government users pioneered the commercial uses of computers in the early 1950s. The first computers sold for commercial-type applications were used in the military. (UNIVAC number 2, for example, went to the Air Force in 1952, for use in inventory management and logistics applications.)



other axis, projects are distributed by the extent of their departure from current practice, from marginal, incremental improvements on current technology to truly radical leaps into the unknown.

By definition, basic research is undertaken with no concrete application in mind, but rather to add to the general stock of knowledge. Ultimately, of course, basic research may influence both incremental and radical commercial innovations. The results of the most basic research might be scattered somewhat randomly along the "nature-of-innovation" axis. Applied research and development, by contrast, are focused on particular results, and the objectives of the organization undertaking the project play a much greater role in determining the outcome of the effort. For that reason, innovations resulting from applied research and development projects are depicted in this figure as clustered along particular areas of the nature-of-innovation axis that are related to the interests of the R&D sponsors.

Commercial projects tend to be concentrated in the lower right quadrant of the diagram. Conversely, public support grows proportionately more important as more basic, radical projects are considered, moving up and to the left in the diagram. The results of pure basic research will tend to be scattered along the entire nature-of-innovation axis. But, as more applied research is considered, it will be the most "far-out," radical projects unlikely to attract the interest of private sponsors where public resources will make a difference in determining whether or not the project is undertaken.

Such radical "blue sky" projects may have relatively little existing stock of trained manpower to draw upon. Whole new sets of skills and expertise may have to be created. The people who embody the fruits of this very costly investment can easily pull up stakes and migrate elsewhere. Thus in precisely the most radical, costly, and risky projects, the difficulties of capturing the payoff may be the greatest.

If one considers technology policy as a tool for joining public support for more basic research to the less radical, developmental effort most profitable for private interests, the varying character of national technology policies might be sketched in figure 6-1. In Japan the government-sponsored cooperative R&D projects are a direct bridge of sorts between upper left and lower right, between government-funded basic effort and privately sponsored development projects.

In the United States the link between government-sponsored basic research undertaken in universities and private development has been

less direct. If military interests in research and development are located in the upper right quadrant (that is, the development of radical new weapons systems yielding qualitative strategic advantage), then participation by both industry and academia on such projects has provided an indirect link between the public radical/basic and private incremental/development orientations.

Public investment in the basic and radical has always been linked to private investment in development of the practical. When far-out government research projects and starry-eyed university research have begun to pan out, commercial firms have frequently "bought in" to the concepts by hiring the persons involved. On a more mundane daily basis, by recruiting graduate students trained in more exotic academic research funded out of the public coffers, commercial firms have maintained a continuous inflow of good, basic, new ideas without much of the large and relatively unprofitable (from a single firm's perspective) investment that would otherwise have been required.[4]

It is at the most daring leading edge that government research support continues to play its crucial role. These projects are too risky, too long-term, and too little of their results can be kept within the firm, for companies to be much interested in investing in them. *Basic, precompetitive, radical, long-term*—these are the adjectives that describe the types of research where public support can be most important in supporting a social investment that otherwise might not be made or made at a considerably slower rate.[5]

4. There is a growing body of literature on the statistical relationship between federal contract research and development performed in the private sector and both productivity and private R&D effort. Such studies have generally found small but significant direct effects on private productivity and a considerably more important indirect effect in stimulating private R&D. See David M. Levy and Nestor E. Terleckyj, "Effects of Government R&D on Private R&D Investment and Productivity: A Macroeconomic Analysis," *Bell Journal of Economics*, vol. 14 (Autumn 1983), pp. 551–61; Edwin Mansfield, "R&D and Innovation: Some Empirical Findings," in Zvi Griliches, ed., *R&D, Patents, and Productivity* (University of Chicago Press, 1984), pp. 127–48; and Zvi Griliches, "Productivity, R&D, and Basic Research at the Firm Level in the 1970s," *American Economic Review*, vol. 76 (March 1986), pp. 141–61. For an alternative analysis, see Frank R. Lichtenberg, "The Relationship Between Federal Contract R&D and Company R&D," *American Economic Review*, vol. 74 (May 1954, *Papers and Proceedings, 1983*), pp. 73–78.

5. Several researchers have found that a general slowdown in basic industrial R&D coincided with the decline of federal R&D support in the 1970s. See, for example, Edwin Mansfield, "Basic Research and Productivity Increase in Manufacturing," *American Economic Review*, vol. 70 (December 1980), pp. 863–73; and Griliches, "Productivity, R&D, and Basic Research."



## The Present: Probing the Technological Frontier

Computers are a thriving industry in the late 1980s; shipments amount to almost 1½ percent of the U.S. gross national product.[6] Sustained and continuous technological innovation explains the dynamism of this sector, and—despite a temporary setback dealt by the economic slowdown of the mid-1980s—continued long-term growth near historical rates is probable well into the indefinite future.

Amid this prosperity and growth, are government policies to support innovation superfluous? After all, the U.S. computer industry is constantly turning out new and more powerful products. Why should government fund research and development when the competitive pressures in private industry already seem so effective in generating this constant stream of innovation?

The answer is not simple. American industry certainly continues to be effective in introducing new, technology-based products. Much of this innovation, however, takes the form of marginal, incremental improvements on established technologies. The fundamental aspects of a bread-and-butter business computer of 1985 were not terribly different from the designs of 1965. Some marginal architectural improvements were made, and enormous improvements in component cost and performance were achieved, but essentially the designs represent a much improved embodiment of concepts that have been floating around for decades. When one looks carefully at the most radical, truly revolutionary concepts that are still quite experimental in nature and just beginning to come to market, a rather different impression emerges.

"New wave" computer products include high-speed communications networks linking multiple computers (or even multiple processors within a single computer), systems and languages using artificial intelligence (AI) concepts, special computers designed to run this AI programming efficiently, and ever more powerful supercomputers. All these products draw heavily on a continuing legacy of government-funded research support, and many of the first commercial sales continue to be made to government users.

A November 1986 advertisement by Texas Instruments (TI) in *Scientific American* makes this linkage explicit:

At the heart of Knowledge Technologies [Texas Instruments' new

6. See table 2-2.

line of high-performance AI computers] lies the development of a pioneering semiconductor chip. We developed it under contract to the U.S. Government for use in aerospace and defense, but its impact will be felt in all areas. One of its first commercial applications will be to enhance the power and performance of the TI Explorer computer, already one of the world's most advanced AI development tools. Also, it will add new members to the Explorer family of products.[7]

Even today, public support primes the pump of tomorrow's commercial technology.

### *Issues for a National Technology Policy*

Currently economic theory does not go much beyond explaining why public policies to increase investments in some types of research (particularly long-term, basic research) might be socially useful. Empirical studies (including this one) have repeatedly suggested that fairly dramatic underinvestment in R&D is often the outcome of laissez faire. In many respects, it is not very useful to debate this point. Economic, political, and social forces have made government support for high technology a given of the political economy of an advanced industrial country in the late twentieth century. Discussion, then, must necessarily focus on the details of how governments support technology.

FOCUSED SUPPORT FOR RESEARCH. The economic arguments for public support for R&D primarily revolve around three issues: the inability of firms to totally capture all returns on technology investments, economies of scale in the use of new technology and their consequences, and the difficulties of capital markets in dealing with very risky and costly projects.[8] Policies to correct the imperfections of real-world markets

7. Advertisement run in *Scientific American*, vol. 255 (November 1986). Other key elements of the Explorer computer's design are licensed from MIT, where they were developed with DARPA support.

8. One such difficulty involves the issue of moral hazard, first raised in Arrow's classic 1962 article. Kenneth J. Arrow, "Economic Welfare and the Allocation of Resources for Invention," in National Bureau of Economic Research, *The Rate and Direction of Inventive Activity: Economic and Social Factors* (Princeton University Press, 1962). If an inventor is able to completely shift the risk of an R&D project by selling all the equity in his venture in competitive capital markets, he will also shed the incentive to perform the R&D in the most efficient possible fashion. On the other hand, if constrained to retain some minimum equity share in the venture, suboptimal allocation of capital may result.



should address the concrete details of these three problems. If the purpose of public support for research and development is to ensure that socially worthwhile R&D investments are made that otherwise might not be, then public resources should be directed to the areas where appropriability problems are greatest (that is, basic, high-risk research and radically innovative, leading-edge projects).

Such considerations argue against using an R&D tax credit as the sole instrument of a technology policy. The strength of the R&D tax credit is that it marries market forces to public tax expenditures. But this strength is also a weakness since an objective of public support ought to be to direct resources into worthwhile areas that the market does not find privately profitable. The R&D tax credit is a relatively blunt instrument. It tends to produce overinvestment (from the social viewpoint) in projects where returns are most easily captured and continued underinvestment in projects that are most difficult to appropriate privately.[9] Sufficient resources can be directed into the hard-to-capture areas only by vastly overinvesting in easily captured research and development, if a tax credit were to be used as the sole instrument of policy.

This is not to say that some R&D tax credit may not be valuable. For most kinds of R&D—basic, applied, and development—there is a general tendency for social return to exceed private return. Some level of tax credit is a useful measure to correct for this fact. But a tax subsidy can direct resources into the areas with large differences between private

9. This argument is easily made in a more rigorous fashion. Let the total social return to development expenditures, $E_D$, be given by $R_D(E_D)$; the social return to basic research be given by $R_B(E_B)$. Let the per unit cost of R&D effort be $r$. Also, let $R'_D$, $R'_B > 0$; $R''_D$, $R''_B < 0$ (diminishing marginal returns to R&D effort). It is assumed that fraction $c_D$ of the social return to development investment cannot be captured privately, fraction $c_B$ of basic research, and that $1 \geq c_B > c_D \geq 0$. Let a rate of subsidy of $s$ be granted to all private R&D expenditure. Then profit maximization implies investment in R&D up to the point where

$$R'_D = \frac{(1-s)}{(1-c_D)}r \quad \text{and} \quad R'_B = \frac{(1-s)}{(1-c_B)}r.$$

Social optimality argues for sufficient investment such that the left-hand side, in both cases, is equated to $r$. Thus, because $c_D$ and $c_B$ are different, setting $s$ such that just the right amount of $D$ takes place implies continued underinvestment in $B$, while sufficient $B$ is undertaken at the cost of excessive $D$. If $c_D$ and $c_B$ are very different (that is, $c_B$ close to 0 and $c_B$ close to 1), the problem will be especially great. In principle, different values of $s$ could be applied to the two categories of expenditure, but this would be impractical given the impossibility of defining or enforcing a rigorous separation between research and development.

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and social returns—particularly basic and risky, far-out projects—only by pulling far too many resources into the easy, already profitable types of projects. Public policy ought to be designed to favor research in general, as well as those specific types and areas of R&D activity where both the payoff and the obstacles to private capture of that return seem greatest.

The large social rate of return reaped from all U.S. investments in computer technology, while not unheard of, appears to be greater than the returns available in certain other sectors. Because there is no market mechanism that necessarily directs resources into research areas with the greatest social returns and because social return on investment in a technology may be quite different from private return, large disparities between the social returns on alternative research expenditures may exist. Therefore, some form of targeting is inevitable when actions are based on assessments of relative social return. Those with government research dollars to dispense well realize that they are charged with putting that money where, in their judgment, it will do the most good. Their professional assessment is what plays a key role in approving projects. In practice, targeting decisions of sorts are made routinely on a daily basis.

THE COOPERATION-COMPETITION MIX. An effective technology policy may seek to encourage a mixture of cooperation and competition among private firms and between industry and academia. By encouraging cooperation on the least appropriable, basic elements of technology, more long-range research with a potential broad economic impact on industry may be undertaken. Joint research involving industry and universities can focus on commercially important (but difficult to capture for private advantage) themes that firms would otherwise neglect.

Yet a competitive market has always been essential in increasing the pace of computer innovation. A sheltered monopoly has less incentive to innovate than a firm feeling the hot breath of competition on its neck. The best evidence of the desirability of maintaining a competitive market for downstream products, even when firms share considerable research, is the history of otherwise superficially similar technology policies in Europe and Japan.

MULTIPLE SOURCES OF R&D SUPPORT. Diversity in funding sources and in research has a positive value. The history of support for technology in the United States and Japan, where different supporters of high technology have pursued distinctly different research agendas, is one of



good and not-so-good decisions being made by each group. In the United States if one group had been the supreme arbiter of research policy, ENIAC, UNIVAC (universal automatic computer), Whirlwind, and other significant technology projects might never have been undertaken. Even within a single large and closely managed organization like IBM, various forms of competition in research have been carefully used to reduce the probability that any single erroneous decision will have a lasting impact on the fortunes of the organization. Because research is such a small part of the total expenditure required to develop a new product, funding multiple approaches in the research stage is a cheap way to reduce the risks involved in innovation.

MILITARY VERSUS CIVILIAN CONTROL OF RESEARCH INVESTMENT. After the first great wave of investment in technology during World War II, voices within the U.S. government argued for continuing federal support for technology but with a focus on helping industry to develop useful commercial applications. For a brief time the experiment flourished: the first fully operational computer in the United States came out of this effort.

At the time the economic arguments for investing public resources in technology had yet to be articulated. Scarcely a glimmer of the full glory of the harvest to be reaped from the unprecedented wartime effort was then visible. To powerful critics, this experiment represented a needless meddling with market forces. The effort was publicly crushed, and since then—except for basic research in universities and health research—federal support for technology has had to be justified in terms of some well-defined mission of the federal government. Defense, a cure for cancer, and putting a man on the moon are objectives deemed appropriate by Uncle Sam. But helping to build the technological infrastructure needed for a competitive American industry has not traditionally been on his list.

Since the mid-1950s, the only politically acceptable way to support the technological development of U.S. industry has been to declare it militarily strategic. Rather intricate contortions have sometimes been required to justify military expenditures that are fundamentally intended to build up the general level of industrial and scientific capacity in the U.S. economy. Unfortunately, such "frills" are often among the first casualties during military budget cutting. From the perspective of military planners, technology investments, like other items in the defense budget, are judged in terms of concrete, deliverable results and perfor-

mance. The general benefits to the economy are counted only insofar as they show up in the cost and performance of other military budget items. Thus for the military, like private industry, the widespread diffusion of new technology into industry is best enjoyed if someone else's technology dollar has paid for the show.

Cyclically, almost predictably, years of budget plenty end and lean years begin. Ax in hand, military cost cutters go after items of least immediate operational relevance, and military-sponsored research programs defensively must show near-term results. DARPA, for example, has weathered several of these cycles: tolerance for visionary research projects with only indirect military relevance has been followed by budgetary distress and renewed emphasis on immediate applications, engineering, and working hardware.

Pressures to focus defense R&D on specific military missions are a constant of the political process. Even today, when economic competition with Japan is high on the agenda of projects like DARPA's strategic computing program, military research expenditure is constantly forced to define itself in terms of concrete military applications. Strategic computing, for example, must channel a significant portion of its funds to traditional military contractors, and evidence of production of concrete military applications—deliverables—must be presented to justify continued funding. For DARPA the pendulum has swung back toward applications and development.[10] These constraints in all likelihood make for a less effective policy in support of the long-term, industrial technology base.

Even in good times it is not always clear that the talk of "fallout" and economic benefits is well founded. The problem with using such appeals to justify military investments is that they cloud the issues on which judgments are to be made. If the investment were justifiable on purely military grounds, no such appeal would be required. If it were justifiable on purely economic grounds, then a rationale replete with numbers and bottom lines would have to be constructed. By moving in the no-man's-land between strategic and economic benefit, a project can slip past the snares of both economists and tough-minded generals.

Is there any way to evaluate the effectiveness of a policy that explicitly

10. See Tim Carrington, "Pentagon's Research Agency Will Shift Emphasis to Building Arms Prototypes," *Wall Street Journal*, September 16, 1986; and George Leopold, "Will Shifts at DARPA Weaken Basic Research?" *Electronics*, December 9, 1985, p. 47.



seeks out technology with long-range commercial value (rather than relying on the incidental spillover from military projects) in giving American industry a competitive edge? This is the heart of the matter, and unfortunately there are no easy answers.

One of the continuing preoccupations of scholars studying the relationships between research and development activity and technological advance has been to characterize the differential effects of different types of R&D activity on productivity and innovation. There have been two broad types of studies—*statistical analyses*, which examine correlations between different categories of expenditure and measures of innovation, given some assumed web of causation; and *case studies*, which attempt to trace the links between particular advances and the concrete research programs from which they resulted.

Each type of study has major limitations. The statistical studies have been hampered by the limited amount, poor quality, and high level of aggregation of data on research and development expenditure. If all the major linkages among the different types of R&D expenditure, product sales, and innovation were examined, a very detailed breakdown of research funded as well as performed by government, industry, and universities would be needed. The segmentation of research and development by funders reflects the fact that a funder's objectives in all likelihood influence the outcome of an R&D project. Because of economically significant differences in private appropriability, research and development probably should be broken down further into basic, applied, and development expenditure. But because of limited data, even the best statistical studies rarely attempt to do more than disaggregate between basic research and applied and development activity or, as an alternative, between all privately and publicly financed research and development within industry.

University-based research is generally not even considered when studies unravel these relationships within industry, although—as the development of computer technology makes strikingly clear—major outputs from government-funded R&D programs have repeatedly been transferred from universities to industry with few dollars changing hands and little in the way of a paper trail. A 1986 study of industrial research and development that distinguishes between military and nonmilitary funding roils these troubled waters more. Frank Lichtenberg argues that military R&D expenditures, by stimulating contract-seeking research and development on the part of private firms expecting future procure-

ment contracts, substantially undercount the true magnitude of resources drawn into the military R&D effort.[11]

A broad survey of the origins of key elements of computer hardware reveals significant links between major concepts and pioneering government-supported projects. The innovations cover a variety of technical areas. Many important companies repeatedly declined even subsidized opportunities to explore these new technologies in the early years, and if the federal government had not stepped in, private interest alone would certainly have generated much slower development of the technology.

Spinoffs from military computer projects continue to have a profound impact on the development of commercial computer technology. But it is far from clear that channeling such funding through military programs maximizes commercial spinoffs. Funneling R&D funding through military sponsors may even impede commercial applications in some respects. For example, compilations of patent statistics show that research and development connected to military sponsors yields considerably fewer patents of commercial interest than do equivalent expenditures by other government agencies.[12]

### *The Case for Civilian Objectives*

A highly trained and motivated civilian agency, if given the mandate of cooperating with American industry and academia to improve the

11. Frank R. Lichtenberg, "Private Investment in R&D to Signal Ability to Perform Government Contracts" (draft, Columbia University, Graduate School of Business, 1986). See also Mansfield, "Basic Research and Productivity Increase in Manufacturing"; Griliches, "Productivity, R&D, and Basic Research"; and E. Wolff and M. I. Nadiri, "Interindustry Effects and the Return to R and D in Manufacturing," 1984, and "Linkage Structure and Research and Development," 1984, as cited in M. Ishaq Nadiri, "Economics of R and D Investment," *NBER Reporter* (Summer 1985).

12. In 1976 only 1 percent of the unexpired patents owned and available for licensing from the Air Force were actually licensed, as were 1 percent for the Navy, 3 percent for the Army, and 4 percent for NASA. This compared with 11 percent for the Energy Research and Development Administration (now the Energy Department), 13 percent for Interior, 15 percent for Commerce, 10 percent for Agriculture, and 23 percent for the Department of Health, Education, and Welfare. See Federal Council for Science and Technology, *Report on Government Patent Policy, Combined December 31, 1973, through September 30, 1976* (Government Printing Office, 1976), pp. 440–41.

However, since the practice of Defense and NASA has generally been to grant to contractors patent rights when requested, this may merely mean that the best inventions are harvested by contractors, leaving the chaff for the government sponsor. This is consistent with the fact that the Army and NASA, which show higher percentages of their patents actually licensed, give away their rights somewhat less frequently. See chapter 4.



long-term technological future of the American economy, ought to be able to get at least as big a commercial bang for the federal research buck as a Pentagon planner looking for an economic hook to pull in additional support for a new weapons system. If the streamlined efficiency of defense programs was an unassailable article of faith, Pentagon budget administrators might be the best that could be, and the secondary importance of commercial objectives to many such projects might be offset by the superior performance of Defense Department administrators on technology investments. But this is not the case.

Support for industrial technology ought to be decoupled from a volatile military budget. Military perceptions of the size and nature of the external military threat change. The needs of American industry do not necessarily march in harmony with the rhythm of international military competition. Military objectives, like commercial objectives, revolve around concrete goals, like delivering weapons systems on schedule, on target, and on budget. Inevitably, the long-term, the basic, the not immediately tangible are given short shrift when funding shrinks and purely military objectives are used for triage among wounded programs.

Moreover, military and commercial objectives can conflict. Research on weapons systems, by nature, imposes a curtain of secrecy over developments that might have beneficial consequences for industry if widely diffused. During the 1940s and 1950s, scientists running military programs actively worked to propagate the new technology as widely as possible among American industry. This played a major role in the rapid development of American industrial muscle in computers. Conversely, more recent attempts to control the export of information across national boundaries may directly limit the distribution and application of useful results within those boundaries.

On occasion, control can prove indirectly counterproductive to economic interest. America's attempt to deny the French nuclear program access to a supercomputer in the mid-1960s (a futile attempt) sparked crash development programs and ultimately reduced American computer sales in foreign markets in later years.

Important military systems requirements may sometimes have small commercial value. Resistance to radiation and electromagnetic pulse, for example, yield a relatively small return in commercial markets but are a central focus in products aimed at military markets.

Military specifications and test procedures sometimes drive technology in the wrong direction—that is, away from the most important

commercial markets. For many years military testing and "burn-in" requirements may have been an obstacle to adoption of statistical quality-control techniques in the American electronics industry.[13] Military testing requirements for electronics packages emphasize extreme and rapid changes in temperature—relevant perhaps to aircraft, but not normally encountered in most natural environments. On the other hand, the test most relevant to commercial products—simulating the stress of switching power on and off—is not included in military specifications.[14]

The American armed forces have strongly supported research on manufacturing technology. They generally fund programs that reduce the cost of military weapons systems, which, like other highly specialized capital goods, are usually produced in small lots or batches. They have not focused on reducing costs in large-scale mass production, as is typical in consumer markets. Some have argued that similar focus has affected the type of semiconductor research supported by military programs and has made such spending less useful to commercial industry.[15]

Finally, government subsidy to industrial computer research (which largely comes out of U.S. military budgets) is distributed in a highly uneven fashion. The firms that receive assistance are not always the ones most able to successfully introduce new innovations commercially. DARPA funding for the strategic computing program, for example, has departed from past practice and placed a heavy emphasis on supporting research in the large, specialized defense systems contractors. These firms, had they the inclination, may not have the ability to rapidly commercialize new technology in the marketplace. The skills needed to compete effectively in the military market may be quite different from the ones needed to succeed in the commercial market, and programs that channel research resources to more heavily defense-oriented contractors may yield proportionately less commercial return.

13. See Kenneth Flamm, "Internationalization in the Semiconductor Industry," in Joseph Grunwald and Kenneth Flamm, *The Global Factory: Foreign Assembly in International Trade* (Brookings, 1985), p. 122.

14. Tobias Naegele, "Englemeier: 'Mil Specs Drive People in the Wrong Direction,' " *Electronics*, October 28, 1985, p. 57.

15. The case is made in Leslie Brueckner with Michael Borrus, "Assessing the Commercial Impact of the VHSIC (Very High Speed Integrated Circuit) Program," Roundtable on the International Economy (University of California at Berkeley, 1984); and Jay Stowsky, "Competing with the Pentagon," *World Policy Journal*, vol. 3 (Fall 1986), pp. 697–72. The semiconductor manufacturer Intel is reported to have opposed VHSIC on similar grounds. Glen R. Fong, "The Potential for Industrial Policy: Lessons from the Very High Speed Integrated Circuit Program," *Journal of Policy Analysis and Management*, vol. 5 (Winter 1986), p. 277.



### *A Missing Link*

Outside of the military research agencies (and, to a lesser extent, the National Aeronautics and Space Administration and the Department of Energy), the government organization that spends the most research cash in the national interest has been the National Science Foundation. Recently the NSF has shifted a larger share of its budget into more applied, engineering programs with a distinct emphasis on cooperation with industry. This shift clearly reflects its (and the government's) growing preoccupation with maintaining industrial competitiveness in an increasingly challenging international marketplace.

Supporting industrial technology, however, is not what the NSF was set up to do. Its first and most outspoken proponent, Vannevar Bush, believed that basic research divorced from the immediate needs of commercial industry was the essential foundation for applied forms of technological progress. This conviction prompted his call for the establishment of the NSF. Forging direct links between university research and applied industrial objectives is far from the foundation's original charter of supporting basic scientific knowledge, unfettered by any requirement that it show industrial relevance. To quote Bush, "basic research is essentially noncommercial in nature. It will not receive the attention it requires if left to industry."[16] The whole decisionmaking structure of the NSF was set up around academics making judgments about the academic research projects of their peers based purely on scientific merit: profitability and potential industrial application were of secondary concern if any.

In the late 1960s the NSF began to edge toward other priorities. Applying technology to solve social problems emerged as an objective appropriate to the times, and Congress in 1968 amended the NSF's charter to include applied research among the agency's concerns. Much of this thrust fizzled out in the late 1970s.[17] By the 1980s the challenge of newly felt international competition sparked a new emphasis on economic relevance, and the shift began toward engineering, particularly the NSF's Engineering Research Center program, which has been the focus for recent growth in agency funding.

A wholesale shift in NSF priorities toward applied research, engi-

16. Vannevar Bush, *Science: The Endless Frontier*, Report to the President on a Program for Postwar Scientific Research (GPO, 1945), p. 17.

17. See NSF Advisory Committee on Merit Review, *Final Report*, NSF 86-93 (Washington: NSF, 1986), pp. 11–12.

neering, and advanced development projects represents a major change in course for the NSF. If one agrees with Bush that basic research deserves its own organization, then NSF's new focus on industrial technology fills one space by emptying another. Judging what areas of applied industrial research merit long-term support is a very different type of judgment—in part an economic one—than the pure consideration of intellectual merit around which NSF procedures are organized.

A vacuum now surrounds an important social purpose: to support applied research and early development of the new technologies required to keep America's industries economically fit. The industrial technology base is no one agency's explicit target. All responsible public servants in the various research-funding bodies, of course, realize that the technology base is a fundamental national interest, even if it is not explicitly written down in the *Federal Handbook*. So the missions and charters of the various agencies are stretched whenever a particularly worthwhile investment comes along.

## The Future: New Technology for American Industry

How can national policy better serve the common national interest in expanding and improving American society's investment in technology? For decades this question was rarely asked. The United States' lead with respect to other countries' technologies was so great, its economic muscle so strong, that the unforeseen fallout from its huge investments in military R&D was quite sufficient to keep the nation's industrial technology second to none. Today, however, competitors have caught up to the United States in important areas and may even have passed it in others. They are investing sums comparable in magnitude to U.S. military R&D programs in commercially oriented research ventures.

As chapter 2 made clear, public investments in computer technology are justifiable on purely economic grounds. The wisest investments are in the most basic research and high-risk, radically innovative projects. To plant technological seed corn that industry can harvest later, the areas of research with the greatest commercial and industrial potential should be selected. And the selection mechanism should be workable in the institutional context of American industry.

What is the simplest national policy to achieve these objectives? It is to use public resources to partially offset the costs of joint industrial



investment in basic and "generic" technology development. The policy is clearly workable. Concerns about increased international competition have already prompted American business to form cooperative, joint research associations in unprecedented numbers. Today support for joint, precompetitive, generic R&D is quite widespread. Influential figures within even that most entrepreneurial of American high-technology sectors, the beleaguered American semiconductor industry, are now calling for a massive new cooperative research program to tackle the technological roots of its current distress.[18] With little publicity, powerful bureaucrats are taking steps on their own to fund such programs.[19] Never has the moment seemed better to explore a new direction, an experiment in policy, and never have the stakes seemed higher.

Underwriting some portion of these ventures with federal funds or tax expenditures would pull more resources into the applied research and generic technology development undertaken by these organizations, as well as raise the overall level of R&D investment. Moreover, such a policy would guide public funds into areas that industry believes to be productive, but where the benefits are difficult to capture and individual, private efforts therefore unlikely to succeed.

If, say, 40 percent of the investment is offset through the tax system or direct funding, firms will still be providing the remaining 60 percent of the funding by risking their own resources. The resources so invested will then be funneled to the projects thought to have the highest payoff for the industry as a whole. A funding mechanism that shares costs and risks creates built-in incentives for allocating resources efficiently.

And, of course, jointly pooled resources will be directed into precisely those areas—basic, and generic, precompetitive research—that are least likely to be appropriated (and hence funded) by individual firms. Perhaps the most eloquent testimony to the effectiveness of these arrangements is the extent to which their use grew in Japan, where they were first

18. See "Editor's Overview," and Harvey Brooks, "National Science Policy and Technology Innovation," in Ralph Landau and Nathan Rosenberg, eds., *The Positive Sun Strategy: Harnessing Technology for Economic Growth* (National Academy Press, 1986), pp. 15, 156–57, and Richard R. Nelson, *High-Technology Policies: A Five-Nation Comparison*, American Enterprise Institute Studies in Economic Policy (Washington, D.C.: AEI, 1984), p. 73. See also Richard Bumbrick, "Semitech Gets SIA Go-Ahead; Target Gov't, Ind. for Funds," *Electronic News*, November 24, 1986.

19. Administrators in the Department of Defense and the National Science Foundation, for example, recently budgeted contributions of $1.1 and $0.1 million dollars respectively to the nonprofit Semiconductor Research Corporation for precisely these reasons.

devised and tested, and is now being emulated in Europe and the United States.

The institutional mechanisms required to establish such a program, in some sense, already exist. The Stevenson-Wydler Technology Innovation Act of 1980 called for the establishment of a cooperative generic technology program, new organizations within the executive branch to study and stimulate the development of technology applicable to industrial needs, and the organization of centers for the development of industrial technology at universities and other nonprofit institutions. The Commerce Department was empowered to fund up to three-quarters of project costs at the centers for industrial technology, which were eventually intended to become self-supporting.[20]

The Commerce Department, however, never implemented most of the provisions of this law. This was a political decision. But the fragmented and sprawling bureaucracy of the Commerce Department may not be the best organization to implement such a program. It already wears too many hats: protector of declining American industries, champion for small business, forecaster of the weather, compiler of economic and demographic statistics, promoter of American exports, registrar of patents, traffic cop for the radio spectrum, extoller of the virtues of tourism in the United States. Although the Commerce Department does have isolated centers of technological expertise—particularly the National Bureau of Standards—overall it has not displayed a solid understanding of, or informed interest in, important technological issues. A more effective steward of America's technological edge in world markets might be a smaller, totally dedicated organization.

### *The National Technology Office*

The purpose of this National Technology Office (NTO) would be to monitor the international competitiveness of American products both on the market and under development, report on its observations for public debate, facilitate the formation of joint research ventures within American industry, and serve as custodian of the public interest in those associations formed to carry out joint industrial research. The organization might resemble a civilian DARPA, charged with stimulating long-term investment in key industrial technologies. The private sector could define areas for investment by forming joint research associations with particular objectives and then seeking partial federal financial support. The role of the NTO would be to approve the bona fides of the group seeking partial support—something like approving the tax exemption of a nonprofit organization—and to certify that the project involved the kind of activity that the program was intended to assist—namely, generic, precommercial technology development.

20. See Office of Technology Assessment, *Information Technology R&D: Critical Trends and Issues* (Washington, D.C.: OTA, 1985), pp. 32–33; and J. A. Alic, "The Federal Role in Commercial Technology Development," *Technovation*, vol. 4 (1986), pp. 266–67.



The precise method of backing private investments, be it tax credits for eligible R&D or direct grants in important but imperfectly appropriable technology projects, is less important than the principle. Business and society must be partners if needed investment in America's future are to be made. They must share the risks and rewards of their long-term technology investments. Each must contribute if they are to jointly prosper.

As a clearinghouse for joint research, the NTO could eliminate obvious duplication and aid the flow of nonproprietary information within industry and between industry and academia. And it would be in an invaluable position to mobilize American industry in the face of new technological challenges. It could constantly scan the technological horizon, identify important new developments, sound the alarm, or propose an initiative when necessary. And it would safeguard the public interest in the collusive arrangements that cooperative research must, by definition, involve. Joint industrial research programs generally require some form of antitrust exemption. The National Technology Office might offer cooperatives antitrust relief, in addition to partial matching of funding on eligible projects, as a quid pro quo for a public representative (perhaps drawn from its ranks) on their boards to keep an eye on the public interest. That interest would include the responsible expenditure of public funds and the guarantee of adequate downstream competition in products developed privately using this research base. To ensure equality of opportunity and absence of political bias, such ventures would be open on equal terms to all firms willing to meet whatever transparent and nondiscriminatory financial and participatory requirements were established.

Setting up the NTO would require skilled personnel able to develop useful working relationships with industry. Technically knowledgeable specialists would mix with economic and financial analysts within the

organization. To keep its technical skills at the cutting edge of innovation, it might have an internal research capacity, not unlike MITI's relationship with its internal industrial science laboratories.

Fortunately, there already exists within the federal government a small but competent band of technical specialists that has extensive experience working with industry on joint research projects. That group, of course, is the National Bureau of Standards, the same NBS that back in the 1950s built the first fully operational stored program computer in the United States. Today it is deeply involved in applied research on manufacturing technologies, computers, and robotics.

Standards issues are reshaping commercial markets and technology. With General Motors, the NBS is testing an architecture for future automated manufacturing systems as part of the program to develop the Manufacturing Automation Protocol (MAP). With the cooperation of other firms, the NBS is working on computerized manufacturing and design standards such as the integrated graphics exchange standard (IGES) and the product data definition interchange (PDDI) standard. In addition, it is doing work under contract to DARPA as part of the strategic computing program.[21]

One simple solution, then, would be to take part of the technical core of the NBS, transplant it to a new organization, and greatly expand the scope of the work those specialists currently direct. This technical staff and trained economic and financial analysts would make up a small hybrid organization—something like a cross between the current NBS, Arthur D. Little, the Congressional Budget Office, and the Office of Technology Assessment. The charter of the new organization would be to monitor the technological health of American industry, keep abreast of developments abroad, issue periodic reports, and formulate long-range proposals for accelerating the advanced research and development needed to maintain the quality of America's industrial technology base.

The President's Commission on Industrial Competitiveness released a report in 1985 that advocated more radical changes. It favored the creation of a "superagency" to preside as czar over *all* nonmilitary research.[22] The National Technology Office, however, would have as its

21. NBS is doing research on speech coarticulation as part of the speech understanding segment of the program. See Defense Advanced Research Projects Agency, *Strategic Computing: First Annual Report* (Arlington, VA.: DARPA, 1985), p. 9.

22. See President's Commission on Industrial Competitiveness, *Global Competition: The New Reality*, vol. 1: *Report of the President's Commission on Industrial Competitiveness* (GPO, 1985), pp. 22–23, 51.



only concern the state of American industrial technology. Although the only group in government with this specific charge, it would be one of many influences in the government's research policy community. The NTO would supplement, not replace, the voices of DARPA, the NSF, and NASA. These agencies could get back to performing the missions for which they were designed. No longer would they be involved in the contorted justifications required to deal with unmet social needs outside their charters.

How might the NTO mobilize the collective efforts of American industry in the face of technological challenges from abroad? The following scenario describes one set of circumstances in which the NTO might function as a catalytic agent for joint industrial research.

### *Synchrotrons and Other Developments*

The NTO might play a vital role in the development of high-intensity X-ray lithography apparatus to etch microelectronic devices with very fine, dense features. Such devices are essential for future generations of high-performance semiconductors in general, and computer circuitry in particular. The technology is still experimental, and a practical system awaits the development of a compact, superconducting, synchrotron storage ring. (Developing this equipment might dovetail nicely with applied research on newly discovered superconducting materials.) This equipment, once developed, may be quite expensive—perhaps $10 million for a synchrotron X-ray source and the capacity to etch six to ten semiconductor wafers at once.[23] Although most semiconductor and computer firms are interested in the technology, few can afford to risk the large investments required by such a costly and highly speculative project.

As of mid-1986 this technology was being explored on a large scale with government support in West Germany and Japan but not in the United States.[24] IBM has been cooperating with the Brookhaven National Laboratories of the Department of Energy in the development of

23. The cost estimate was given in a presentation by Peter Rose of the Eaton Corporation at the National Research Council Seminar on "Advanced Processing of Electronic Materials in the United States and Japan: A State of the Art Review and Its Policy Implications," Washington, D.C., June 4, 1986.

24. See National Research Council, *State of the Art Reviews: Advanced Processing of Electronic Materials in the United States and Japan* (Washington, D.C.: National Academy Press, 1986), p. 24.

a synchrotron-based etching system, but this appears to be a modest effort falling well short of the large investment required to develop a practical prototype machine.

In the summer of 1986 MITI formed a cooperative research venture company, K. K. Sortec, to develop compact, synchrotron-based X-ray etching systems. This effort was part of the Japan Key Technology Center, a new organization founded in the fall of 1985 and authorized to fund up to 70 percent of the cost of private research ventures. Seventy percent of the funding for the ten-year venture, with a budget now pushing $5 million, is coming from the government, the remainder from a consortium of thirteen Japanese firms.[25] Another synchrotron project is under way within NTT.

Many U.S. electronics specialists (including those of the National Research Council) believe synchrotrons merit further exploration, but no major private venture in this costly and speculative area had been announced in the United States as of early spring 1987. An alert, disciplined, and well-motivated organization like the NTO—even with less government support (say a 30 percent share)—could quickly take the lead in mobilizing U.S. firms in ventures similar to those of the Japanese.

Other areas where support for joint industrial research might improve the competitiveness of American industry abound. In early 1987 American electronics producers appealed to the government for support for a joint venture to develop advanced semiconductor manufacturing technology. This is another logical entry point for an NTO-type program. Why not have industry organize a Stevenson-Wydler-style joint venture to direct such an R&D effort, with perhaps half of the expense shared with the federal government? Industry, rather than Pentagon planners, could select the most commercially promising areas and direct its collective efforts there.

Other frontier technologies that might usefully be explored in this fashion for the collective benefit of American high-tech industry include new and exotic materials (high-temperature superconductors, ceramics, diamond films), optical switches and transmission, experimental software production systems, and molecular engineering methods. The

25. The companies include computer producers NEC, Hitachi, and Fujitsu. Other members are Matsushita, Mitsubishi, Sanyo, Sharp, Sony, Oki Electric, Sumitomo, Toshiba, Nikon, and Canon. See Charles L. Cohen, "Japan Kicks Off X-Ray Fab Project," *Electronics*, August 7, 1986, p. 44.



ultimate authority on the wisdom of particular choices would be American industry. It would have its own cash at risk—a powerful incentive to choose what will prove the most commercially successful.

In the final analysis the question may be whether the United States is willing to change the way it does research. For forty years it has avoided difficult questions about the role of government in the development of technology by relying on the military services as the custodians of the nation's economic future. The military option is workable within the context of U.S. institutions, but it fails the other tests of a good technology policy. The cyclical feast and famine of the military budget process inevitably directs research and development away from long-term projects of only indirect military interest when the crunch eventually comes. Worse yet, economic judgments about long-term commercial promise are not part of these budget choices. In fact, appeals to commercial fallout are generally the sign of a military project that cannot be justified on its security merits, just as appeals to defense applications are the sure sign of a commercial project that isn't making it as a business proposition. We are left with a muddle—too little accountability and too much pork barrel.

The military option kept the United States moving along nicely in an era when it was the king of a one-lane road, but it needs revision as the country turns onto a four-lane superhighway crowded with other drivers jockeying for position. Panels of respected American scientists and engineers have recently published a virtual blizzard of reports that warn of dangers on the technological frontier in a number of important areas.[26]

### *Opening Markets in High-Technology Products*

To meet the challenge of the competitive international environment, the United States must keep open global markets for its technology-intensive products. This should be the country's first priority. The protectionist backlash that is unleashed in the United States by foreign

26. National Academy of Sciences, National Research Council, *High-Technology Ceramics in Japan* (Washington, D.C.: National Academy Press, 1984); J. Nevins and others, *JTECH Panel Report on Mechatronics in Japan* (La Jolla, Calif.: Science Applications International Corporation, 1985); H. Wieder and others, *JTECH Panel Report on Opto- & Microelectronics* (La Jolla, Calif.: Science Applications International Corporation, 1985); and G. Turin and others, *JTECH Panel Report on Telecommunications Technology in Japan* (La Jolla, Calif.: Science Applications International Corporation, 1986).

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targeting policies, and more blatant moves around the world to favor national firms in national markets for advanced products, is a short-sighted reaction that works against the United States' long-term objectives. A recent trend toward erecting protectionist barriers around high-technology sectors in the United States (in semiconductors and advanced machine tools, for example) may work against the long-term interests of American high tech by setting dangerous precedents for the nation's trading partners and competitors.

What may be needed is a set of agreed upon principles of nondiscrimination on the basis of national origin analogous to those ruling trade in conventional goods, as in the GATT. At a minimum, the United States should continue to work for a reciprocal opening of markets in technology-intensive goods that would explicitly strengthen provisions related to government-controlled procurement. Exceptions based on national security considerations should be few and well defined.

Attempts to eliminate subsidies to research and development from international trade in high-tech products—given the compelling economic arguments for, and history of, government involvement in fostering technology development—seem fruitless. A more useful approach might be to open up programs to fund the development of technologies used in internationally traded products, on a reciprocal basis, with the United States' major industrial trade partners. Indeed, bilateral initiatives of this sort have already been discussed publicly. In 1978 some elements in the military and the Department of State favored a bilateral accord permitting Japanese participation in the Defense Department's VHSIC (very high speed integrated circuit) program in exchange for U.S. participation in MITI's VLSI (very large scale integrated circuit) program. Opposition within the Defense Department ultimately killed this exchange, but the proposal demonstrated that serious interest in such accords exists.[27]

Opening up U.S. research programs to industrial competitors on a reciprocal basis would be particularly advantageous in the computer field. All the major industrialized economies are currently funding computer technology programs of comparable sizes. Making the results of these programs available across national boundaries would improve the efficiency of global expenditures on computer research and development by reducing duplication, help others avoid blind alleys, and generally improve the flow of basic, precompetitive information.

27. See Jill Hills, "Foreign Policy and Technology: The Japan–US Japan–Britain and Japan–EEC Technology Agreements," *Political Studies*, vol. 31 (June 1983), pp. 212–15.



The Japanese have edged in this direction by seeking international academic participation in their Fifth Generation program, as have the Europeans by accepting IBM and the Digital Equipment Corporation as participants in the Esprit projects of the European Community. In a sense, the United States already has, too, by training in its universities so many of the world's computer scientists. If all current computer support programs in industrialized countries were opened to firms from the other countries active in the field, each country (including the United States) would gain access to research with funding exceeding that of its own national program.

This piecemeal approach toward reducing the impact of any single nation's public R&D support on the competitive position of its firms in international markets seems a useful step toward rationalizing global R&D and improving the potential welfare of all. But the risk of international competition in high-tech products heating up into open trade war, with individual countries closing off their research and markets from competitors, will still exist.

Ultimately, all would lose with such a balkanization of national markets for high-tech goods. Policies designed to slow the international diffusion of technology may well inhibit advance within domestic industry, and by limiting foreign sales reduce the incentive to invest in the development of new technology and the competitiveness of the industries involved. Rather than attempting to erect a fortress around existing national technologies in a futile attempt to preserve some static advantage, international competition could more fruitfully focus on developing new technology as quickly as possible, in order to stay one step ahead in the game.

The most reasonable outcome might be a gradual series of small, partial, and perhaps bilateral steps that liberalize participation in and access to research programs in some equitable fashion. For example, the Japanese government might be asked to permit American firms to participate in its synchrotron research in exchange for entry by Japanese companies into American joint venture research in another high-risk, exploratory area of semiconductor manufacturing technology.[28] The

28. The United States retains a lead in key areas of exploratory research on microelectronic manufacturing technology, including ion implantation, thin-film epitaxy,

exact outlines of a finished package remain unclear, but it is time to start thinking about what sorts of experiments will lead policy down a productive path.

The challenge for an increasingly technology-intensive American economy will be to steer itself away from the worst, and toward the best, of all possible high-tech worlds. In the worst case—fractious international discord over trade in advanced products—a heavy lid would be slammed over free access to information, U.S. borders would be sealed against the entry of new foreign products, and, overall, use of new technology and the rate of technological progress would slow measurably.

In the best case, international economic rivalry would be channeled into competition based on innovation and differentiation; an ever greater variety of useful products would become available to all people. The greatest fruits from continued growth would then flow to those countries that were best able to nurture innovation and to meet the demands of a wide and sophisticated global marketplace for quality, reliability, and utility. In such a world, basic scientific information would flow freely, international cooperation on fundamental research would be the rule rather than the exception, and competition would focus on the socially beneficial provision of variety and quality.

The choice of futures is America's to make. The only certainty is that the global economy in the next few decades will be tied to technology on a scale never seen before. The development of the computer will perhaps be remembered as the first large step down this road.

and film deposition and etching. See National Research Council, *State of the Art Reviews: Advanced Processing of Electronic Materials*, pp. 10, 16, 20.

APPENDIX A

# Modeling the Cost of Information Processing Capacity

THIS APPENDIX uses an approach based on production theory to assess the magnitude of improvements in the price and performance of computer systems. Computers are viewed as durable capital goods producing a flow of information processing services, whose utility as an input to the production of other goods and services can be characterized by a single, scalar value. (The flow of services is assumed to be proportional to this index of information processing capacity, IP.)

From a simplified, stylized model of a computer (see figure 2-1) an expression that links system performance to the performance of its component parts may be derived.[1] The single most important parameter affecting the performance of a computer system is the speed of its various component subsystems.[2] The speed of an information processing device

1. This approach is based on the work of the respected computer scientist David J. Kuck. See "Computer System Capacity," section 2.5, in David J. Kuck, *The Structure of Computers and Computations*, vol. 1 (John Wiley and Sons, 1978), pp. 155–69. More complex performance models view a computer system as a network of queues and evaluate its behavior using either analytic methods or numerical simulation models. For a useful overview of the use of such models at IBM, see Yonathan Bard and Charles H. Sauer, "IBM Contributions to Computer Performance Modeling," *IBM Journal of Research and Development*, vol. 25 (September 1981), pp. 562–70.

2. See Harold S. Stone and others, "Hardware Systems," in Bruce W. Arden, ed., *What Can Be Automated?* (Cambridge: MIT Press, 1980), pp. 404–09; C. Gordon Bell and Allen Newell, *Computer Structures: Readings and Examples* (McGraw-Hill, 1971), pp. 49–52; Daniel P. Siewiorek, C. Gordon Bell, and Allen Newell, *Computer Structures: Principles and Examples* (McGraw-Hill, 1982), pp. 42–61; and C. Gordon Bell, J. Craig Mudge, and John E. McNamara, *Computer Engineering: A DEC View of Hardware Systems Design* (Bedford, Mass.: Digital Press, 1978), app. 3.

# *Restructuring American Foreign Policy*

JOHN D. STEINBRUNER
EDITOR

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CHAPTER FIVE

# *Rationalizing Technology Investments*

KENNETH FLAMM
THOMAS L. MCNAUGHER

The application of advanced technology is critical simultaneously to the security, the economic prosperity, and the international stature of the United States. Though that judgment is difficult to prove with standard statistics, virtually no one would doubt it in summarizing the experience of the past four decades or in anticipating the next four.

It is certainly apparent in studies of the prime symbol and leading instance of technical change, the electronic computer. The cost of information processing capacity has declined for decades at a stunning rate, averaging more than 20 percent a year, perhaps 25 percent in real terms. This is roughly an order of magnitude greater than the most rapid price decreases registered in the peak decades of the first great industrial revolution at the dawn of the nineteenth century. Shipments of computer hardware alone are now rapidly approaching 2 percent of U.S. gross national product, and a reasonable calculation suggests that one year's technological advance in computer engineering brings with it a benefit of 0.3 to 0.8 percent of GNP.[1] In an era when annual growth rates in national income are 2 to 3 percent, this constitutes an extraordinarily important contribution to improving the standard of living. Moreover, since the trend of technological advance will continue unabated for at least another decade and because information is an essential element of

1. See Kenneth Flamm, *Targeting the Computer: Government Support and International Competition* (Brookings, 1987), pp. 32–35. An approximation to this number may be arrived at by noting that a 25 percent reduction in the cost of computer shipments, which are approaching 2 percent of GNP, is 0.5 percent of GNP. Calculations that take into account the sensitivity of computer demand to price, and use a range of plausible values for the price elasticity of demand and the annual rate of technology-driven improvement in price performance, yield the ranges mentioned in the text.

most economic activity, the basic structure and operating patterns of modern economies should be far more profoundly affected than we have yet been able to appreciate—and similarly for military forces.

Public policies to support the development of advanced technology in the United States have historically been primarily preoccupied with national security applications.[2] As the United States invested in its military establishment in the years following World War II, commercial industries were stimulated, largely as an unforeseen outcome.[3] Since that time, as military technologies have matured, the demands of security investment have diverged from those of commercial application, while the broad economic implications of the new technology have become as important to its society as achieving purely military objectives.

Today we live in a different world. Industrial societies that were still recovering from the damage of World War II when the U.S. acquired its general technical advantage have learned to adopt our accomplishments. U.S. businessmen now increasingly complain that American innovations in basic science and technology are being commercialized abroad with little of the profit flowing back into the pockets of Americans whose tax dollars financed much of the initial investment. These industrial rivals, moreover, have come to undertake their own technical investments in amounts comparable to the United States', and since they direct a higher proportion of it to commercial purposes, their investments now exceed our own in that area.[4] Meanwhile, defense research and development seems less effective than it once was in generating commercial benefits and is itself more in need of the discipline and innovative impulses that well-developed markets provide.

Changing circumstances call for changing policies. A new world of

2. One of the major historical exceptions was the U.S. government's support for agricultural research, begun in the nineteenth century. The limited ability of small farmers to undertake such investments, and the difficulties of capturing and commercializing the results in an era when farmers were a potent political force, foreshadow some of the dynamic that is driving government to take a more supportive role in industrial R&D today.

3. Though the scale and significance may be unprecedented, military investment was also crucial in advancing American industrial technology in the last century. Public investment in state-of-the-art armories and munitions factories spurred the growth of the metalworking and machine tool industry. The American system of large-scale manufacture was honed on the military market: Samuel Colt's pioneering use of interchangeable parts in mass-produced revolvers was an experiment paid for by military procurement. See, for example, David A. Hounshell, *From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States* (Johns Hopkins University Press, 1984), chap. 1.

4. National Science Board, *Science and Engineering Indicators, 1987* (Government Printing Office, 1987), p. 3.



peers and competitors means that, more than ever before, public investments in technologies expected to benefit either the U.S. industrial base or the defense effort must be effective and efficient. And the increasing maturity of much U.S. military technology, and tightening budgets, mean military R&D can no longer be expected to build the commercial technology base. Where military investment is in frontier technologies, expanding the outer envelope of technological advance, defense investments can help create technologies that will ultimately benefit industry. But the existence of nimble and able foreign competitors means that speed and effectiveness are essential in reaping commercial returns, and the defense establishment is simply not organized for rapid and efficient application. The core defense technologies—ships, aircraft, and tracked vehicles—are more mature, increasingly specialized, and inherently remote from commercial markets. The expense of each item and the limited scale of production mean that the relationship between the evolution of design and the ultimate product must be very different. For both economic and security reasons the United States must reconsider the way it organizes investments in technical innovation.

While the details are still uncertain and disputed, the guiding principles of necessary reforms seem clear enough. Public support for developing the commercial technology base ought to be defined and justified on its own terms. It should not depend on a concocted claim that it is needed to maintain national security, an appeal designed to tap the deep pockets of the defense establishment. Conversely, military requirements for technology ought to be defended in military terms, and not draped with claims of commercial spillovers when the logic of military necessity seems weak. Programs to support either objective—commercial or military—should be designed with efficiency and effectiveness in mind. An effective military research and development effort means scraping away the bureaucratic incrustations that have grown over defense R&D contracting in recent years and providing for the operational experience required to master increasingly complex technical applications. Improving the effectiveness of investment in commercial R&D means creating an agenda responsive to the technological needs of industry. It also means experimenting with new forms of organization designed to increase cooperation within industry and between industry and academic research institutions.

## THE HERITAGE

World War II marked a fundamental change in the importance of R&D in American economic life and in public support for technological

innovation. The war involved an unprecedented mobilization of American scientists and engineers in a vast military R&D project.[5] Federal expenditures on R&D rose from $97 million in fiscal year 1940 to $1.38 billion in 1944 and $1.6 billion in 1945. After the war, support continued; in 1947 the military spent $500 million (out of $625 million in federal research funds) on R&D, 80 percent of which was contracted to industrial and university laboratories.[6] Before World War II the government had paid for 15 to 20 percent of U.S. research; after the war it funded more than half of a vastly expanded national effort.[7] After falling sharply in the 1970s, federal funding today pays for more R&D than does funding from the private sector.[8]

It was in this postwar environment that the computer industry took off, and this industry's success has become a symbol of the nation's entry into the era of high technology. But the nation's initial experience with commercial spillover from rapidly changing military technologies began after World War I, with airplanes and, especially, their engines. Although federal support for the aircraft industry was proportionally smaller and less direct than it would be for the computer industry, it was crucial to the industry's survival.

## *Aircraft and Engines*

The story of innovation in the aircraft industry and the crucial role played by defense spending has been told in detail by others.[9] Here it is

5. For example, in 1935 less than 4 percent of Bell Laboratories personnel worked on military projects. In 1943 roughly 75 percent of the Bell staff and 80 percent of the Bell Labs budget went to defense activities. Bell Telephone Laboratories, *A History of Engineering and Science in the Bell System*, vol. 2: *National Service in War and Peace (1925–1975)* (Murray Hill, N.J.: Bell Telephone Laboratories, 1978), pp. 11, 356.

6. Roughly half the 1944 expenditure, $730 million, was accounted for by the Manhattan Project. National Science Foundation, *Federal Funds for Science, II. The Federal Research and Development Budget, Fiscal Years 1952 and 1953* (GPO, 1953), pp. 11–13.

7. Flamm, *Targeting the Computer*, p. 6.

8. National Science Foundation, *National Patterns of Science and Technology Resources, 1987*, NSF 88-305 (GPO, 1988), table B-5.

9. See Irving Brinton Holley, Jr., *Buying Aircraft: Matériel Procurement for the Army Air Forces* (Office of the Chief of Military History, Department of the Army, 1964); David C. Mowery and Nathan Rosenberg, "The Commercial Aircraft Industry," in Richard R. Nelson, ed., *Government and Technical Progress: A Cross-Industry Analysis* (Pergamon, 1982), pp. 101–61; Robert Schlaifer and S. D. Heron, *Development of Aircraft Engines and Fuels* (Harvard University Graduate School of Business Administration, 1950); and R. Miller and David Sawers, *The Technical Development of Modern Aviation* (London: Routledge and Kegan Paul, 1968).



necessary only to draw a few conclusions. First, federal support was essential to the development of an industry in what has always been an exceptionally volatile and risky business, with its unpredictable demand and the steadily rising costs of developing new models.[10] But the greatest source of risk has been technological advance in a host of aircraft subelements, which has produced rapid obsolescence in existing models, great market uncertainty, and a constant need to face the risks of technological research.[11]

In his comprehensive history of early aircraft engine development, Robert Schlaifer argued that it was "not only inevitable but desirable that the government should guide the general course of development, since the record shows that private industry cannot be relied upon even to advocate, let alone finance, the development of every type of needed materiel."[12] Thus federal—largely military—support for R&D was instrumental in advancing the state of the art in aviation.

Military funding went well beyond support for scientific advance, subsidizing the industry at all levels. Income from military production contracts served to buffer aircraft firms from ebbs and flows in the commercial side of their business. In the 1930s every major aircraft manufacturer, including Douglas, whose DC-3 dominated the commercial market, did at least half, and often much more, of its business (measured as a percentage of sales) with the military.[13] Profit from military

10. Today a manufacturer that decides to build a new model "is literally betting the company, because the size of the investment may exceed the company's entire net worth." John Newhouse, *The Sporty Game* (Knopf, 1982), p. 3.

11. Before World War II the most startling advances lay in improving the thrust and trimming the weight of aircraft engines, although improvements in airframe design had only slightly less disruptive effects on the industry's advance. An ingenious combination of these advances gave Douglas dominance in the industry after it introduced the DC-3 in the mid-1930s. The development of jet engines just before World War II introduced a new phase in aircraft design, complemented somewhat later by the introduction of electronics components. The costs and complexity of new models rose accordingly.

12. "Nowhere in the world," he continued, "did a single established engine builder undertake the development of turbojets until either persuaded to do so by government, as in Germany, or confronted with a demonstrably successful turbojet developed with extensive government aid as in England and in the United States." Schlaifer and Heron, *Development of Aircraft Engines*, pp. 27–28, 29.

13. During the 1930s, for example, when the Douglas DC-3 dominated commercial aircraft markets, "the greater unit value of military aircraft enabled other producers to avoid financial disaster." Mowery and Rosenberg, "Commercial Aircraft Industry," p. 108.

aircraft production contracts tended to serve as a hidden subsidy for R&D.[14]

For engines, in which technological change was most pronounced, the military services were "the main market . . . particularly for new types and models."[15] This held true in the jet as well as the piston age. Demonstrated just before World War II, jet engines saw considerable development during the war, all for the military market. After the war, work on strategic bombers contributed substantially to the development of turboprop as well as turbojet engines. And the early high-bypass-ratio engines crucial to commercial aviation in the 1960s were first developed and built for the military.[16]

The military's drive for high-quality products tended to pull the commercial side of the industry along in its wake. Although the military purchased commercial or near-commercial aircraft like the DC-3 and the KC-135 (which, with some modification, became Boeing's very successful 707), the aircraft industry benefited more broadly as a "borrower" of technologies successfully applied in military aircraft.[17] It is in this sense that funding for purely military R&D paid dividends to commercial aviation. That firms were engaged in developing both military and commercial aircraft was obviously crucial, since industrialists were in a position to make rapid and informed judgments about when best to move a new technology into commercial ventures.

The way federal support was provided also made a difference. Schlaifer, for example, distinguished between federal funding of R&D and federal performance of R&D. "A private firm must maintain a proper balance in directing the general program of development," but "a government establishment tends to become a collection of specialists, each promoting his specialty whatever the effect on more necessary objectives." Thus, army engine projects failed "to sacrifice individual features of merit in

14. See Holley, *Buying Aircraft*, p. 24.

15. Schlaifer and Heron, *Development of Aircraft Engines*, p. 7.

16. Significantly, by this time aviation and engine firms had acquired their own R&D facilities. Thus the industry contributed 32 percent of the financing for development of the turbofan engine, with the military contributing 55 percent and the Federal Aeronautics Administration and the National Aeronautics and Space Administration 13 percent. Mowery and Rosenberg, "Commercial Aircraft Industry," p. 131.

17. Mowery and Rosenberg use the word *borrower* in three contexts. First, "significant innovations in commercial aircraft design . . . were originally developed by manufacturers of airframes and engines for military applications." Second, "important benefits are reaped by airframe and engine manufacturers who are able to share development, or less often, production tooling costs between military and civilian designs that are less closely related." Third, aircraft "have benefited to an unusual extent from technological developments in other industries." Ibid., p. 102.



order to hasten the success of the engine as a whole."[18] As principal customer, the government had the power to control "even the work done by private firms in all its details, but development [of engines] was fully successful only when the services gave the firms all possible freedom in deciding on details of design and development."[19]

The most successful vehicle for funding aeronautical research was not a military organization per se but rather the National Advisory Committee on Aeronautics (NACA), created in 1915 and funded separately from military service budgets, just as its successor, the National Aeronautics and Space Administration (NASA) has been funded separately from the Defense Department. Although NACA's formal mission was to attend to problems facing military and air mail aircraft, its work covered "problems of aerodynamics and aeronautics common to both military and commercial aircraft."[20] NACA's elaborate test and research facilities, principally at Langley Field, Virginia, and Moffett Field, California, provided test data to the industry as well as the military. Equally important, these research centers served "as training schools for the vitally necessary aeronautical engineers of industry."[21] NACA's greatest contribution was made before World War II; by the 1950s, commercial aircraft firms had developed their own R&D facilities.

Significantly, NACA's strong suit was not only or even mostly basic research. Indeed, much of the basic research and inventing in aeronautics was done outside the United States, notably in Germany, immediately before and during World War II. Rather, NACA excelled in taking basic scientific ideas to a point at which "they could easily be applied by manufacturers."[22]

### The Computer

The great technological strides made during the war convinced the military officers, scientists, and engineers involved that continuing support

18. Schlaifer and Heron, *Development of Aircraft Engines*, pp. 23, 24.

19. Ibid., p. 8. "Government intervention in technical details," he continued, "always led to very considerable delay, and often to a poorer product in the end."

20. Mowery and Rosenberg, "Commercial Aircraft Industry," p. 128.

21. Holley, *Buying Aircraft*, p. 23.

22. See "Statement Submitted by Dr. David R. H. Sawers, Princeton University, in *Economic Concentration*, Hearings before the Subcommittee on Antitrust and Monopoly, Senate Committee on the Judiciary, 89 Cong., 1 sess. (GPO, 1965), app. 7, pt. 3, p. 1505. Sawers goes on to argue that by 1945 "German designers had built or were testing nearly all the ideas" that were to be incorporated in American aircraft in the next twenty years. This research was mostly financed by the German government.

for research (albeit at more reasonable peacetime levels of expenditure) could pay great strategic, economic, and social dividends. The computer industry became a principal recipient of this support, and rapid progress in computing technology was directly linked to government-sponsored research projects.

Between 1945 and 1955 the U.S. government became the dominant (almost exclusive) force in computer development; all major computer technology projects in the United States were supported by government or military users or both. Between 1955 and 1965 the emergence and rapid growth of a commercial, business-oriented market for computers drastically reduced the government share of the overall marketplace. Government users still dominated in high-performance, large-scale scientific computers, however, and advanced technology projects paid for by the federal authorities accounted for much of the continued rapid technological advance.

From 1965 to 1975, as the commercial market matured, the emerging economics of competition in this technology-intensive industry dominated developments in the commercial marketplace. A shakeout occurred, and a few firms firmly entrenched in specific market niches survived. Entry into the competition in hardware was largely confined to firms specializing in new low-end applications (often based on minicomputers), and high-end, very large scale computers (supercomputers). The government played little direct role in the entry of the cheaper, low-end hardware producers, but a very direct and significant one in the supercomputer marketplace. The government's overall support of advances in technology generally declined, however, consistent with a broader pattern of reduced support for research caused by the financial burden of the Vietnam War. Federal support for computer R&D now focused on advanced, precommercial concepts and more exotic technologies, and on support for basic research.

From 1975 to the present, falling hardware costs have led to the emergence of the computer as an inexpensive, mass-produced good. Competition in the commercial marketplace has dominated the continued restructuring of the industry at home and abroad.

In the early years of the computer industry, the government's role in spurring technological development was so pervasive that its critical role in industrial and technological development is virtually self-evident.[23] But the tremendous growth in the commercial markets since the 1960s

23. A skeptical reader may wish to consult Kenneth Flamm, *Targeting the Computer*; and Flamm, *Creating the Computer: Government, Industry, and High Technology* (Brookings, 1988).



makes current government funding for R&D and procurement of computers now seem of minor proportions.

However, for experimental computer technology too visionary or too costly to be a sound private investment of scarce research dollars, federal support has continued to be crucial. As limits to advances in computer performance using tried-and-tested solutions became evident, the American government again took the lead in supporting research that explored parallel processing, exotic semiconductor materials, and optical and cryogenic components. A new generation of advanced computer products—sophisticated networks, systems based on concepts of artificial intelligence, high-performance graphics, reduced instruction set computer architectures—drawing on government-funded R&D of the 1970s and early 1980s has just begun to come to market. And a heavy new round of investment in advanced computer technology promises further returns.

### *Superconductors*

The discovery in 1986 of new materials that transmit an electrical current without resistance at relatively high temperatures may prove to be the same sort of radical technological breakthrough in the 1990s that the computer proved to be in the 1950s. The transmission of power without loss through heat promises to revolutionize electrical generation and storage. Superconducting digital switches promise levels of circuit density and speed in electronic systems such as computers that would be impossible with conventional elements. Without the need to dissipate heat, magnets of unprecedented power and minimal weight and volume seem attainable. New types of sensors for all types of electromagnetic radiation seem possible by using such devices as Josephson junctions that could previously only function in temperatures maintained by liquid helium. The ability of the new materials to work at much higher temperatures with considerably smaller refrigeration costs, and the possibility that room-temperature operations might one day be feasible, have stirred much commercial interest.

The new materials build on a knowledge base formed by a long-term investment in the theory and application of condensed-matter physics. The phenomenon of superconductivity was discovered in the Netherlands at the beginning of this century.[24] European researchers—primarily in

24. This section draws heavily on Kenneth Flamm, "Government's Role in Computers

the Netherlands, Germany, Britain, and the Soviet Union—made significant advances in exploring the phenomenon in the 1930s. However, the materials used were low-temperature superconductors, requiring refrigeration using liquid helium at 4.2 degrees Kelvin (−490 Farenheit) to exhibit their peculiar characteristics. Before World War II perhaps ten laboratories in the world (two in the Soviet Union) had mastered the exotic technologies required to liquify helium.

Even earlier, superconducting materials had been used in constructing ultrasensitive magnetometers. Germany and the United States invested significant resources in developing infrared detectors in the 1940s, but World War II ended before a production system saw action. Sensors for microwave radiation were also investigated in the 1940s. During the war reliable cryogenic refrigerators were developed and put into volume production. Liquid oxygen, which requires refrigeration to 90 degrees Kelvin, was routinely used in high-altitude fighters by the Allies.

Just after the war ended, about the same time as the new Office of Naval Research turned its attention to computers, cryogenics and superconductors were also placed on its research agenda. Within the first few years of its existence, the ONR had established and funded a major research program in low-temperature physics that was a significant influence in training scientific personnel. Most American workers in the field can trace their roots—or the antecedents of their professors or graduate research programs—to the ONR program.

By 1950 the first practical result of the ONR support—a vastly improved helium liquefier—transformed low-temperature physics into a much less difficult and demanding pursuit. This apparatus, the Collins cryostat, was the backbone of a highly productive low-temperature physics research program begun at the Bell Telephone Laboratories in 1953. In 1954 a team at Bell used this cryostat to push critical temperature for a superconducting niobium-tin alloy to a new high, 18 degrees Kelvin.

Progress in the theory of these new materials was also made during the 1950s, funded in part by Defense Department research contracts. John Bardeen, Leon N. Cooper, and John R. Schrieffer later received the Nobel prize for work supported in part by such a contract. A rash of studies followed in the late 1950s and early 1960s, many funded by the Defense Department, showing superconductivity in a variety of new

and Superconductors," prepared for the U.S. Congress, Office of Technology Assessment, under contract H36470, March 1988. See also U.S. Congress, Office of Technology Assessment, *Commercializing High-Temperature Superconductivity* (GPO, 1988).



materials. Perhaps the most remarkable aspect of this increased understanding is the way in which the locus of technical advance moved from its prewar center in Europe to the United States. This had much to do with the migration of many European physicists to America and the research investments of the government (through the Defense Department in general and the ONR in particular) and the Bell Labs.[25]

Though public investment in superconductivity research had slowed before the discovery of high-temperature superconductors, the military services continued to fund significant efforts until diminishing returns appeared to set in. The major Defense funders were ONR; its sister organizations, the Air Force Office of Scientific Research and the Army Research Office; and the Defense Advanced Research Projects Agency (DARPA). On the civilian side the National Science Foundation (NSF) has been an important source of support since the 1970s, and the discovery in 1987 by Paul Chu at the University of Houston of a material that was superconducting at 95 degrees Kelvin was financed by a NSF research grant. DARPA's involvement with the basic research on materials, in fact, is an excellent example of some of the problems that have made military support for long-term research less forthcoming in recent decades.

DARPA AND THE INTERDISCIPLINARY LABORATORIES. The Advanced Research Projects Agency (DARPA; the "D" for Defense was added in 1972) launched a major initiative into materials research, including superconductors, soon after its formation in 1959.[26] From 1960 to 1962 interdisciplinary laboratories were begun at twelve major American research universities. Funded at $15 million to $20 million annually, the laboratories were intended to strengthen American materials science at the universities. Though solid-state physics and metallurgy were among the interests supported by the laboratories, and superconductivity research was part of the program, the laboratories are best known for building American technical capacities in ceramics, composites, semiconductor materials, laser components, and basic theory. By the mid-1960s their budget had doubled to nearly $30 million annually, and they increased the supply of faculty and post-doctoral researchers at the

25. Paul K. Hoch, "Migration and the Generation of New Scientific Ideas," *Minerva*, vol. 25 (Autumn 1987), pp. 215–17, 225–36.

26. The information in this paragraph and the next is drawn from Richard J. Barber Associates, *The Advanced Research Projects Agency, 1958–1974* (Alexandria, Va.: Defense Technical Information Center, 1975), pp. V-45–V-48, table VI-1.

universities by more than 50 percent, almost doubling the number of graduate students and research assistants.

In the mid-1960s the laboratories originated the concept of coupling with industry to transfer university expertise in basic research to help industry solve problems with defense-related materials. But the Defense Department believed the program was not oriented toward specific defense needs, and the funding pressures of the Vietnam War caused funding to be cut to $4 million in fiscal 1968, though it was to rise again to $15 million in 1969–70. The issue was clearly that too much unfocused research was being done and not enough development. At that point Congress passed the Mansfield amendment mandating that the Defense Department support only research directly related to defense needs. DOD used the amendment as the excuse to begin the process of reducing its investment in the centers.[27]

In fiscal 1972 the program was passed to the NSF, and the centers were renamed the Materials Research Laboratories. In 1973 and 1974 four new MRLs were started, and a fifth began in 1982. From 1977 to 1986, however, eight were terminated, leaving nine still in operation today. The link to current research is that the latest high-temperature superconductors are ceramics, and the processing techniques for these materials will undoubtedly draw heavily on the knowledge base built in these centers.

With the interdisciplinary laboratories gone, DARPA's Materials Office turned increasingly to more applied science. New materials for use in military applications were investigated, and some support was given to the Navy's Annapolis research laboratory, where a superconducting motor and generator propulsion system were being developed. While propulsion systems using high-temperature superconductors will undoubtedly build on the experience gained in this program, DARPA concluded in the mid-1970s that the field had reached a dead end and moved out of superconductivity research.

APPLICATIONS. In the late 1950s and early 1960s government agencies began to seek applications for low-temperature superconductors. The National Security Agency funded a program to develop superconducting switch elements, but devices that depended on relatively slow phase

27. The Mansfield amendment was clearly used to shut off projects in competition for scarce budgetary resources during the Vietnam War. An internal Defense study found that only 4 percent of DOD projects failed its definition of the Mansfield test (and none was in DARPA). Ibid., pp. VIII-20–VIII-21, VIII-59.



changes in superconducting materials were too slow to compete with the rapidly evolving semiconductor electronics, another discipline that greatly benefited from defense research investments. In 1962 a different and much faster mechanism usable in a superconducting switch was set out by Brian D. Josephson in a Nobel prize–winning paper. The NSA mounted a major effort to build prototype computer components using the Josephson effect at IBM in the mid-1970s, an effort that grew to about $20 million a year by 1981, with the agency paying a quarter of the cost. Continued advances in increasing speed and reducing power dissipation in semiconductor technology again doomed the effort, which was saddled with the additional difficulties of working at liquid helium temperatures, and the project was terminated in 1983.[28] But if a new project using the high-temperature materials is begun—which seems likely—it will build on research on the structure of devices and the manufacturing techniques learned in these earlier efforts.

In the 1960s the predecessors of the Energy Department began to develop magnets with extremely strong fields by using low-temperature superconducting materials. These turned out to be the first practical application of superconductivity, and were used in particle accelerators and detectors. Difficult manufacturing problems were solved and materials improved through collaboration between the energy research laboratories and private manufacturers. Today the major commercial application of superconductivity—medical magnetic resonance imaging—uses materials first developed for these earlier magnets. (The other, and much smaller, commercial application is Josephson-effect devices, which draw on technology for superconducting electronics developed at IBM and other organizations as part of the research effort of the 1970s.)

Thus in a pattern typical of the early development of computers and aircraft, the few early commercial applications of superconductivity drew directly on the first applications sponsored by the government. Unlike computers and aircraft, however, superconductors have not yet become a significant large-scale commercial industry.

## THE LOGIC OF GOVERNMENT POLICY

Public support for investment in technological innovation stems from two very different motives. One of these—historically the major justifi-

28. Flamm, "Government's Role in Computers and Superconductors," pp. 50–51.

cation in the United States and the driving force behind investments in computers and aircraft—has been to develop superior technology for use in weapons. The second motive, the basis for the current intense interest in high-temperature superconductors, is that investment in technology can bring economic benefits to society exceeding the private return to those undertaking the investment. In these cases some sort of government subsidy or incentive may be called for as a matter of public policy.

The economic argument for public support of R&D was not articulated until the late 1950s, and such support has only recently gained wide acceptance in this country as a legitimate function of government. The rationale recognizes two main issues. Private firms may be unable to appropriate (that is, capture for their exclusive use) the benefits of certain types of investments in technology, particularly basic research. And ....perfections in capital markets make very risky and costly projects less likely to be undertaken than might be beneficial from society's perspective. Projects that entail radical innovations (as opposed to incremental advances) suffer on both counts, because much of the uncertainty in defining new existing demands can be resolved only by actually developing and marketing a highly innovative good at great cost. Prospecting for profitable innovations on the technological frontier yields information about the nature of demand that is as easily grabbed by claim jumpers as by the risk-taker. Private firms have a considerable incentive to avoid hazarding their own capital in removing these uncertainties. Over time, government support has assumed its greatest role in the most basic research and the most radically innovative projects.

Government has generally played its most important part at the birth and in the infancy of new technology. In superconductors, aircraft, and computers, government programs (and the Bell Labatories, which might in the days before divestiture have best been thought of as a quasi-public source of research support) paid for virtually all the initial work—research, development, and perhaps most significantly the initial market sales. But as commercial products emerged in computers, for example, and commercial markets developed, the volume of commercial sales came to dwarf the government market.

Commercial sales are dominated by an R&D effort that is mainly focused on development, typically five times greater than spending research performed in the computer industry, for example. Thus, even though government pays for perhaps 40 percent of computer-related research in the United States, and maybe 65 to 75 percent of basic research, its share of total computer R&D is only about 20 percent.[29]



It may be appropriate, then, to think of a life cycle in federal support for the development of a new technology. In the earliest days, when there are few trained people and little knowledge, and commercial products are merely a glimmer on some visionary's mental horizon, the government funds most of the research and buys the product. Private individuals would have to bear too much of the cost and risk and get too little of the return (because of imitation or hiring away trained people by others, for example) to make those first, very expensive investments.

But the resulting products can often be adapted at low cost into commercial products, and a new market carved out. After a self-sustaining commercial market has proved itself, private interests are perfectly willing to invest in development, where results take the form of incremental improvements and informal know-how that is more difficult for a competitor to steal. The return is more easily captured for the benefit of the investor risking his resources. In short, in the early, precommercial days of a new technology, government's role is often broad and pervasive. As the technology matures, private interests take over the job of refining the product and directing it toward the commercial niches that they know best.

Computers and aircraft are relatively mature technologies in the later stages of this life cycle. Superconductors are in the early stages. The closest thing to a commercial market for them is in medical instrumentation, and even here the products are still only a few small steps away from their roots in research magnets and sensors. Thus it is natural to expect government-sponsored research to be far more critical and pervasive in the near-term growth of commercial applications.

Our reading of the historical record also provides a corollary. The further from an established product or market a particular technology lies, the more likely an R&D investment will have inappropriable economic consequences or a scale and risk that might rationally motivate government involvement. Econometric studies also show that more basic research has greater social returns. The more mature the technology, the more tailored it is to a well-defined market, and the narrower and closer to product development the effort becomes, the less likely it is that the R&D performed is going to yield far-reaching technological benefits to

29. Flamm, *Targeting the Computer*, pp. 101–05.

the nation. Because significant economic benefits spilling beyond the organization undertaking the project are less likely, the economic rationale for public support is weaker, and (in the cases we know) the role of government in moving the technology forward becomes less critical. Since the broad outlines of the last four decades of American high technology are consistent with this cycle, it is all the more remarkable that one of the key architects of postwar U.S. science policy articulated much of the argument back in the 1940s, when the first great debates over American technology policy occurred.

Dr. Vannevar Bush served as czar over much of the unprecedented wartime R&D effort in the United States. In his capacity as head of the Office of Scientific Research and Development, Bush drew on an extensive background as a practicing engineer and scientist, professor and dean of engineering at the Massachusetts Institute of Technology, consultant to industry and government, and a key participant in the flowering of modern industrial research within corporate America in the 1930s. Though he was a firm believer in the value of markets in directing resources, Bush was an equally stubborn believer that private efforts alone could not produce the research base required by the new industrial technology. When basic research competed for scarce research dollars in a corporation, Bush argued, it would inevitably be cut back in favor of product and process development.[30] Bush's law paralleled the argument outlined above (which was not to be articulated in its modern economic form until 1959) that a private company could less easily capture the benefits of basic research effort than it could the benefits of product development.[31]

To protect basic research from open competition with development efforts, Bush proposed creating a national research foundation to insulate

30. "Applied research and development differs in several important respects from pure science. Since the objective can often be definitely mapped out beforehand, the work lends itself to organized effort. If successful, the results of applied research are of a definitely practical or commercial value. The very heavy expenses of such work are, therefore, undertaken by private organizations only in the hope of ultimately recovering the funds invested. . . . The distinction between applied and pure research is not a hard and fast one, and industrial scientists may tackle specific problems from broad fundamental viewpoints. But it is important to emphasize that there is a perverse law governing research: under the pressure for immediate results, and unless deliberate policies are set up to guard against this, *applied research invariably drives out pure*." See Vannevar Bush, *Science: The Endless Frontier*, A Report to the President on a Program for Postwar Scientific Research (GPO, 1945), p. 77.

31. See Richard R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy*, vol. 67 (June 1959), pp. 297–306.



investments in basic research from the pressures of profitability.[32] Today's National Science Foundation, with its elaborate systems of peer review oriented toward pure intellectual merit and away from economic or commercial return, is the modern legacy of Bush's vision.

Although Bush did not make the point, his law may apply to much technology spending in the public sector as well. In such "mission" agencies as Defense or Energy or NASA, stringent budgets have typically meant cutting back on longer-term, more speculative research in favor of delivering the functioning systems that commanders, or department heads, or mission specialists are clamoring for. The projects most distant from clear or immediate missions are sacrificed—and this too means development is favored over research.

Even within the NSF, the growing awareness and importance of economic "competitiveness" in the 1980s have skewed the budget increasingly toward applications and engineering. The relative share of its traditional grants to individuals for basic research projects has steadily declined in recent years.[33]

If the private sector can be counted on to fund more applied research and development, then, and the public sector has designed institutions such as the NSF and the National Institutes of Health to insulate basic research from the pressures of funding competition, is there yet another significant need that goes undefined? We believe so.[34]

Between the very basic and the very applied lies an ill-defined but critical no man's land in which basic science is first translated into practical new concepts for products and processes. Although the eventual link to commercial returns may be more visible than it was at the basic research stage, the same concerns apply: inexpensive imitation by competitors and the scale and risks required in proving new ideas can lead to the same sort of underinvestment that motivates society to supplement private support for more basic research.

In the American system of R&D, in which basic research is performed mainly in universities and applications and development mainly in private corporations, this middle ground between idea and product is also where linkages between distinct participants, particularly academia and the private sector, are required. Mechanisms for translating the basic research

32. See Bush, *Science*, p. 17.

33. National Science Foundation, *Report on Funding Trends and Balance of Activities: National Science Foundation, 1951–1988*, NSF 88-3 (GPO, 1987), p. 8.

34. Arguments of the sort that follow have been made in Flamm, *Targeting the Computer*, pp. 180–84, and Martin Neil Bailey and Alok K. Chakrabarti, *Innovation and the Productivity Crisis* (Brookings, 1988), pp. 113–18.

of universities into new products developed by our corporations are clearly at the root of current concerns over our ability to translate what is widely perceived to be the world's best system of support for basic science into competitive and timely commercial innovations.[35]

This middle-ground research, where relatively costly investments in developing and proving practical new concepts are made, constitutes the current challenge to public policy. It is here that huge investments were required to convert the theory of computing machines developed in the 1930s into the first working behemoths of the 1950s. This middle ground was where the government poured resources into translating the deepening understanding of aerodynamics, structures, and materials into functioning prototypes of superior flying machines in the decades after the 1920s. This is the middle ground where engineers and scientists currently worry that foreign competitors are poised to pluck basic research on high-temperature superconductors and rush to market with new products.

Yet these are relatively recent preoccupations. Why does a system that seemed to work so well in the 1950s and 1960s now need restructuring? What has changed that makes our traditional reliance on the technologies developed for military systems less effective in pushing the civilian industrial technology base forward?

## CHANGING CIRCUMSTANCES OF MILITARY AND COMMERCIAL R&D

Two changes make the institutions we developed during and after the Second World War less reliable today. One is external: the development of significant technical capacity and challenge by foreign competitors. The other is internal: an increasing divergence in the objectives of military and commercial technology and the decreasing commercial and military returns of investments in defense technology.

### *International Competition*

New technology has raised the American standard of living in three distinctive ways. First, because it has helped our national stock of

35. For example, see Council on Competitiveness, *Picking Up the Pace: The Commercial Challenge to American Innovation* (Washington, D.C., 1988).



resources—people, land, minerals, and capital—produce more and better products than before, it has directly improved our economic welfare.

Second, in an international economy, if Americans "own" a new technology, they can charge foreigners through direct sales of the rights to its use, or indirectly by setting up factories overseas to build products embodying the new technology, or by exporting the products directly and building into the price a premium reflecting the superiority of the good. Such "technological rents," may be a significant component of U.S. national income beyond gains experienced by Americans consuming American goods.[36] Many economists studying the huge increase in American direct foreign investment in the 1950s and 1960s, for example, believe that superior American technology gave U.S. firms the edge required to overcome their natural handicaps in foreign markets and make attractive profits. The handsome returns on these investments contributed to the high U.S. standard of living.

Third, new technology may improve U.S. living standards by lowering the price and improving the performance of imports. Even if foreign suppliers earn a technological rent on their sales to the United States, as long as some of the improvement is passed on to consumers, Americans still gain.

The first and third routes to improved standards of living do not necessarily cost Americans anything. Individuals, firms, and countries invest in creating new technology because they believe that if their investments are successful, they will for a time be able to earn technological rents that will justify research and development investments and a continuing investment in innovation. Typically, however, technological innovation has a way of diffusing. Eventually, when the technology is freely available, one can no longer charge for its use or charge a premium for a product that uses it. The window for collecting technological rent has effectively closed.

So if the United States is willing to wait for the technological developments of other nations to diffuse, or is willing to settle for whatever part of the benefits of innovation is not subtracted by technological rents in imports from abroad, Americans can effectively gain something for nothing. Certainly many foreign competitors have benefited

36. Technological rents can also be collected by American firms in sales of high-technology goods to American consumers, but from the perspective of the nation as a whole this is merely a transfer of income from one group of Americans to another.

from eating the crumbs at the U.S. technology table as they caught up relatively cheaply.

But is waiting a sensible U.S. strategy in a new epoch of intense international competition? For one thing, it means losing out on significant economic returns that can only be gained by investing in technology. Without investment, there is no ownership and control during the window for technological rents. America would be giving up rents that could have been earned, and this country certainly has the human and technical resources that give it a comparative advantage in such investment. Furthermore, America would be losing the potential improvement in productivity that the technology would bring to the use of national resources. Finally, if everyone tried to act as a free rider, global investments in technology would fall, and all would be worse off.

An important part of America's leadership in the global economy in the past four decades has been its willingness to invest in such international "public goods" as technological innovation (especially basic research), even when it realized that significant returns would be captured by others. Once, this mattered less because U.S. firms captured the lion's share of the returns on the least appropriable investments. Today it matters more because others are in a better position to capitalize on U.S. research investments. Of course, America might be content just to continue to invest in the basic science, even if U.S. firms do none of the commercialization and earn no private returns. It is still an investment yielding positive social benefits, since imported cars and computers make lives better. But again, this would mean sacrificing potential technological rents and tolerating lower productivity as Americans waited for the technology they helped build to drift to these shores. This strategy may be better than receiving no technological innovation, but Americans would be far from enjoying the standard of living they could have. And, ...ough impossible to prove, some involvement in creating new technologies is needed ... effectively master their use.

Concern fo ...ational security means that the United States will be involved in hig... technology whether or not it chooses to capitalize on potential economic benefits of that technology. Given that reality, not to take steps to maximize those benefits seems foolish.

The picture is further complicated by the fixed, sunk-cost nature of expenditures on research and development. The costs of developing a new product are not much affected by the scale on which the product is later produced. So volume of sales and size of market can greatly affect the average cost of producing a technology-intensive product: the largest producer may well have the lowest costs.



The economies of scale inherent in the use of technology have made high-technology industries unswervingly international in focus: a significant foreign market can greatly increase the rate of return on relatively fixed R&D investments. In one sample about one-third of the return to private investments in industrial technology was earned in foreign markets.[37] In computers, perhaps 40 to 50 percent of sales and profits are earned from sales abroad.

Thus in the 1970s, when foreign competitors began to achieve technological parity with American firms in such key areas as semiconductors, ceramics, metal alloys, machine tools, and robotics, and sometimes pulled ahead, the situation was particularly galling. For the first time since the end of the war, American firms faced foreign competitors seeking the same technological rents in international markets and sometimes managing to be the first to capture private returns on new technologies. Often the new products and processes capitalized on basic science originating in the United States.

In a less competitive world it did not really matter whether U.S. investments in R&D were made at minimum cost to achieve maximum results. Effective overseas rivals were few, and returns, where and when they materialized, were invariably captured by American firms. Today, however, speed and timing are everything. Lean and hungry foreign competitors have proved their ability to develop and market technologically innovative products. If institutions are not designed to ensure that American R&D investments are effective, efficient, and quickly translatable into technological rents earned by American firms, those returns will be siphoned off into foreign pockets and diminish the ability to sustain the technological base on which American industry depends.

Furthermore, the increasingly pervasive role of high technology in the American economy raises worrisome new concerns. An argument for "strategic" investments in technology to preserve a viable American industry in critical areas threatened by foreign competitors has been given force by the current plight of the American semiconductor industry.

In a world of perfect competition, of course, economic arguments for supporting a strategic industry make little sense. If foreign competitors can produce more cheaply, why shouldn't America take advantage of its comparative edge, purchase the product from them, and shift its resources to industries in which it does have an advantage?

37. Specifically, 29 percent in the chemical industry and 34 percent in other industries. See Edwin Mansfield and others, *Technology Transfer, Productivity, and Economic Policy* (Norton, 1982), pp. 50–52.

High-technology industries, however, are clearly not places to look for perfect competition. If a foreign producer has a monopoly on an advanced technical process or product, industries that use it and that might otherwise be competitive may find themselves at a disadvantage. The foreign producer will generally maximize profit by entering the user industry and thus has the incentive to squeeze out American firms there.[38] Monopoly control also gives him the means.

Until recently, this seemed like a very academic and abstract argument. But the operation of the Semiconductor Trade Agreement, signed by the United States and Japan in 1986, has given it force. One Japanese response to the pact was to form a de facto production cartel for dynamic random access memories (DRAMs), a cartel whose effectiveness was made possible because Japanese producers controlled an overwhelming percentage of DRAM sales in the open market. Restrictions on production and investment helped drive up the price of a key commodity used by a highly important and competitive U.S. computer industry and cost the American economy billions of dollars. It also enabled Japanese producers of semiconductors, who themselves manufacture computers, to make rapid inroads into the American market with lower prices.[39] What seemed a textbook curiosity has become the focus of an industry crisis.

The point is that high-technology products have become so pervasive and essential an element of the U.S. economy that access to them at reasonable and stable prices is every bit as important as access to, say, oil. Maintaining national technical capacity in such areas may be a form of anticartel insurance, a guard against predation by foreign monopolists every bit as sensible as the development of alternative energy sources.

These issues were of little concern in the United States during the first two postwar decades. They have since become vitally important as technical competitors have risen to absorb rents generated by new technologies, even to control access to the new technologies themselves. The need for efficiency in technology investment is obvious. The question is whether that efficiency can be provided by the nation's traditional, defense-oriented approach to technology investment.

38. This was first shown by John M. Vernon and Daniel A. Graham, "Profitability of Monopolization by Vertical Integration," *Journal of Political Economy*, vol. 79 (July–August 1971), pp. 924–25.

39. One study estimated that the Japanese market share in U.S. personal computer stores jumped by 50 percent between the first quarters of 1987 and 1988. See Steven Burke, "U.S. PC Firms Suffer as Japan Reigns Supreme in Memory-Chip Market," *PC Week*, June 7, 1988, p. 166.



## The Military Procurement Muddle

Unfortunately, as the world economy has become more competitive and less tolerant of inefficiency, military R&D has lost many of the characteristics that once helped generate commercial returns. It has lost them largely because it never consciously sought to establish them in the first place. Much of what was good about U.S. military R&D during and just after World War II, especially the way it generated commercial returns, was the product of crisis. During World War II itself, R&D was handled as the nation generally handled war, by mobilizing the scientific community, funding the effort at an extremely high level, and relaxing political accountability to "get the job done." During the 1950s military R&D retained much of this wartime urgency, especially after the bomber gap scare of 1956 and the Soviet launching of Sputnik late in 1957. Thus this decade too was characterized by fiscal and political largesse. In any case, large-scale military R&D *in peacetime* was novel; although the military services had some institutions in place to handle it, Congress and the newly created Defense Department did not. Novelty and urgency together thus left the military R&D effort relatively free from intrusive political oversight.

As this novelty and urgency have passed, politicians have sought to bring military procurement, and with it military R&D, under greater control. The drive has been legitimate and understandable: legitimate because military procurement uses public money to create a public good called national defense, and understandable because weapons acquisition in the 1950s was marked by rampant interservice rivalry and a lack of coherent strategic direction. But the disciplining effort has imposed on military R&D a set of political incentives and an encrusted organizational structure that are relatively insensitive to the increasingly complicated technological undertaking that forms the core of the acquisition process. This has had unfortunate consequences for the quality of U.S. military R&D generally and more specifically for its usefulness in generating commercial returns.

SHORT-TERM PERSPECTIVES. Congress is charged with "providing for the common defense," and as the common defense came increasingly to depend on R&D and procurement, Congress moved to control them. In 1955 only the defense subcommittees of the House and Senate Appropriations Committees routinely reviewed military R&D budgets. In 1959 the Armed Services Committees acquired responsibilities for authorizing

the procurement of some kinds of weapons, but given the small size of its staff, no one expected the Senate Armed Services Committee to oversee R&D.[40] In 1962 the committees acquired precisely this authority, and by the end of the decade subcommittees were examining every corner of the R&D budget.[41] Today program managers for the military's R&D projects spend substantial time testifying on Capitol Hill, briefing the staffs of individual members of Congress, or responding to congressional inquiries.

Although the growing intrusion of American political processes into the oversight of military R&D followed legitimately from the enormous and sustained increase in this component of the federal budget since the early 1950s, Congress has also been pulled in more deeply by the consistently unsatisfactory way the Defense Department establishes program budgets.[42] Deeply institutionalized incentives encourage both industry and military program managers to be optimistic in the early stages of development.[43] Thus long-range budget planning documents, the five-year defense plans, consistently underestimate future program costs, producing the so-called bow wave of escalating procurement costs. Escalating costs force military planners into an often frenetic annual effort to revise their five-year plans, which essentially become annual planning documents. The need for annual reallocation of insufficient funding would itself require legislative action. But from the congressional point of view the Defense Department seems always to mismanage its

40. Raymond H. Dawson, "Congressional Innovation and Intervention in Defense Policy: Legislative Authorization of Weapons Systems," *American Political Science Review*, vol. 56 (March 1962), p. 53.

41. See Andrew Mayer, *The Authorization Process: A Brief History of Authorizing Legislation, with Particular Reference to Its Use by the Armed Services Committees* (Congressional Research Service, 1976), pp. 23–25.

42. Although historically the Armed Services Committees had attended principally to military construction and basing, by the end of the 1950s members had recognized that politically important allocations had moved elsewhere in the defense budget, and the committees shifted focus accordingly. The procurement budget was of course considerably larger than the R&D budget, but most of the important weapons choices were made during the development stage of a new project. Hence the concern for procurement inevitably led to concern for R&D. Prodding the committees was competition among congressional committees and individual members of Congress. Control over defense funds is power; congressional gaming for control has ultimately helped produce a more complicated budget system.

43. See, for example, Merton J. Peck and Frederic M. Scherer, *The Weapons Acquisition Process: An Economic Analysis* (Harvard University Graduate School of Business Administration, 1962), pp. 412–24. For a more recent statement, see Blue Ribbon Commission on Defense Management, *A Quest for Excellence: Final Report to the President* (GPO, 1986), pp. 45–46.



budget, not to mention individual programs whose costs seem forever on the rise. Thus the department needs help, and members of Congress are usually happy to provide it.

What they provide as well, unfortunately, is a short-term perspective that makes sense politically but is anathema to the needs of creative R&D. Congress was relatively generous with military R&D in the 1950s, funding multiple projects and alternative technical approaches to especially risky ventures. Not all duplication was planned in an orderly fashion; some of it was the result of fierce and largely uncontrolled interservice rivalry. Still, congressional generosity created an environment in which developers could explore uncertainties and cope productively with the surprises that so often mark good R&D. And duplication, even some spawned by interservice rivalry, often provided developers and policymakers alike with useful hedges against failure in risky weapons programs.

By the end of the decade, however, most members of Congress had begun to see multiple projects as wasteful duplication, befitting their tendency to justify every dollar spent for its short-term benefit. Thence began a shift away from funding multiple approaches to technical problems in developing weapons and toward the use of analysis to select a single "best" approach. In the early 1960s Robert S. McNamara carried the efficiency drive farthest by seeking not only to eliminate most vestiges of interservice rivalry but also to enforce cooperation where requirements seemed compatible.[44] Within projects, meanwhile, the duplicative work on components and subsystems that had been commonplace in the 1950s was replaced by extended study leading to firm choices imbedded in the elaborate detail of "total package" contracts. To be sure, extended study often proved to be an inadequate guide to the technical challenges posed by sophisticated systems and components.[45] Yet reforms like the Packard Initiatives, inaugurated in 1969 to foster more prototyping of alternative technologies, often fell victim to the

44. Such, for example, was the rationale for the F-111 project, which was intended to fill the Air Force's need for a new fighter bomber and the Navy's need for a new fleet interceptor. Robert F. Coulam, *Illusions of Choice: The F-111 and the Problem of Weapons Acquisition Reform* (Princeton University Press, 1977), esp. chap. 4 and pp. 128–29.

45. The Air Force spent $1 billion, for example, to develop the F-111's Mark II radar, only to prove that original performance specifications could not be met. At much greater cost the aircraft itself was proved to fall short of the full range of expectations written into the original contract. Coulam, *Illusions of Choice*, pp. 128–30; and Allen D. Lee, *A Strategy to Improve the Early Production Phase in Air Force Acquisition Programs*, P-6941-RGI (Santa Monica: Rand Corporation, 1983), pp. 99–101.

search to eliminate wasteful duplication. "The shift from prototype test to analysis as a basis for major management decisions," a Rand Corporation report noted in 1981, "has been almost total."[46]

Obviously, there is nothing wrong with thinking hard at the start of a new project; certainly some of the inefficiencies of the 1950s acquisition process could have been curbed with such extra thought. But it is not clear that all technological uncertainties can be resolved by analysis; indeed, the distinguishing characteristic of R&D is precisely the tendency for problems and breakthroughs to appear by surprise. What is clear is that the rich and varied menu of technologies that reached reasonably advanced development in the 1950s has since been narrowed considerably. Fewer technologies are now being brought to the preproduct stage that proved so important in producing commercial returns in the aircraft and computer industries, and proportionately more investment is going into development.

SOCIALIZATION OF DESIGN. Another perverse consequence of the effort to discipline weapons acquisition has been the absorption of decisionmaking for technical matters into an increasingly complicated Pentagon bureaucracy. The antipathy to wasteful duplication and interservice rivalry helped produce the Defense Reorganization Act of 1958, which among other things enlarged and strengthened an additional layer of defense organizations housed in the Office of the Secretary of Defense (OSD). The effort has continued. The Defense Acquisition Improvement Act of 1986, for example, created an undersecretary of defense for acquisition, whom members of Congress often refer to as the acquisition czar. Yet the reorganization neither eliminated nor redefined the duties of the deputy secretary of defense, who formerly handled acquisition and retains the charter to do so. And in bringing the Office of the Joint Chiefs of Staff and the nation's regional commanders more fully into decisionmaking, the reorganization gave still more agencies an official say in directing military R&D.

Nor has Congress reorganized itself out of the acquisition process. The growth of staffs has only added to the pervasiveness of congressional

46. G. K. Smith and others, *The Use of Prototypes in Weapon System Development*, R-2345-AF (Rand Corporation, 1981), p. 2. Symptomatic of the shift toward analysis has been the marked growth in the length of the "concept formulation" phase of most system development projects. G. K. Smith and E. T. Friedmann, *An Analysis on Weapon System Acquisition Intervals, Past and Present*, R-2605-DR&E/AF (Rand Corporation, 1980), pp. v–vi, 38–39.



oversight. And the interaction between the Pentagon bureaucracy and congressional staffs has created the potential for lobbying by Defense Department agencies as well as defense firms, making it difficult indeed for the acquisition czar or the secretary of defense to fully centralize control over weapons acquisition.

Military program managers who must report frequently to Congress, their own service staffs, and various agencies in OSD at least annually are in no position to leave the defense firms working for them much freedom to make design choices. Rather, they face what the Packard Commission referred to as a "sea of advocates" in the Defense Department, all anxious to see their ideas reflected in ongoing R&D projects. Requirements for new systems, once relatively brief and oriented toward performance, are now long and detailed lists achieved by extensive interagency negotiation. Once written, they are difficult to violate. Thus program managers have a pronounced tendency to sacrifice cost and schedule to meet original performance requirements.[47]

The management of military R&D has, then, become increasingly politicized. At the very least this means that military R&D is likely to move more slowly today than its commercial counterpart. More important, design choices lie in the hands of an elaborate government bureaucracy, which makes R&D management too inflexible. Industrialists are less in charge now, and thus are less likely to be able to move new technologies rapidly into commercial production.

THE MATURATION OF DEFENSE TECHNOLOGIES. Most of the technologies under development in the 1950s—jet engines, supersonic airframes, rockets, computers, and electronics components generally—involved relatively new and unexplored technologies. Developmental risks were quite high, but so was the promise of improved performance and decreasing costs. In the metaphor often used to describe technological evolution, these technologies generally lay on the rapidly rising slope of the S curve.

This is precisely the phase in the technological life cycle when government support is both necessary and most productive, and the military's freewheeling approach to technology development was more or less appropriate to this phase in the cycle. Given in addition the deep involvement of industry's engineers and designers in the work carried

47. For evidence on this point see Edmund Dews and others, *Acquisition Policy Effectiveness: Department of Defense Experience in the 1970s*, R-2516-DR&E (Rand Corporation, 1979), pp. 25–27.

out during this period, it is not surprising that there was a substantial spillover from the defense effort into commercial high-technology enterprise.

The technologies under development in the 1950s remain at the core of the nation's force posture to this day. For the most part, however, they are now mature technologies, well up toward the "flat" of the S curve. As development has become increasingly a matter of refining and perfecting basic technologies, military and commercial designs have diverged; the Air Force's F-100 jet engine, with its high fuel consumption and capacity to rush quickly from idle to full throttle in response to the needs of air combat, has little in common with commercial jet engines, which are designed for low fuel consumption and very steady throttle play. Advances in engine components may of course still spill over into commercial developments. In comparison to the 1950s experience, however, a larger share of defense R&D funding for jet engines and other mature military technologies is now of little use to commercial firms.

RAIDING BASIC RESEARCH. Managerial inflexibility and short-term perspectives are more evident in development than in basic research. Research is a separate enterprise, often carried out by different organizations that face incentives and strictures different from those operating on managers of development projects. Thus defense research spending might arguably still produce commercial spin-offs despite problems in the way the Defense Department handles system and component development.

But what this argument ignores is that commercial returns from defense spending were never wholly or even mostly the result of spending on basic research; indeed, an important force behind the commercialization of defense technologies was defense investment in new applications and the provision of an early market. Equally important, this argument ignores the extent to which the instability built into procurement budgeting makes the defense budget an unreliable source of funding for research. Because procurement costs continue to rise and because Congress is no more anxious than the services to cancel weapons projects, project schedules are usually stretched to lower their annual cost while other parts of the defense budget are raided to fund them. Although the most visible target for such raids has been the "operations and support" line of the defense budget, funding for basic and applied research is equally vulnerable.



That funding for research has tended to rise and fall disproportionately in relation to the Pentagon's overall R&D budget (see figure 5-1) suggests that raiding is more likely when budgets are shrinking.[48] But even this may not reflect the entire reality. In particular, money appropriated for research may in fact be used to fund project-related development. The same pressure would also appear to operate in the industry, where the character of so-called independent R&D spending has changed over time: "The main criterion for reimbursement used to be the innovativeness of the work; today the controlling question is apt to be whether industry's R&D is sufficiently related to an ongoing weapons program."[49]

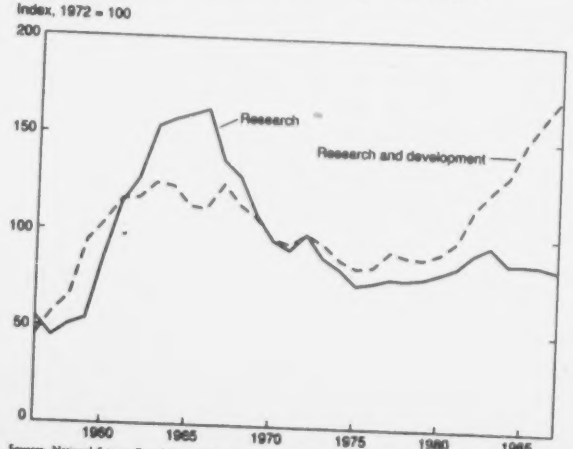
The diminished commercial returns to defense R&D may reflect a recent trend toward spending relatively less on research, even in times of rising budgets. In figure 5-1, for example, funding for research did not rise proportionately with the pronounced increase in R&D funding initiated by the Reagan administration. The contrast with 1958–66 is especially stark. Among other things, the contrast reflects different management styles in the Defense Department. Robert S. McNamara wielded considerable control over the budget and insisted on substantial funding of basic research; Casper W. Weinberger left the services free to manage their own budgets, and they chose to emphasize projects rather than research.

At bottom, the bow wave is symptomatic of fundamental instability in the way the Defense Department budgets for weapons acquisition, R&D in particular. Project costs are habitually underestimated at their start, later forcing the services to scramble for money from whatever spending category can be raided. The most obvious source of project funding is readiness; another is research. If the nation needs a stable effort to develop its technology base, the defense budget is not the place to lodge the effort.

48. For a discussion, see U.S. Congress, Office of Technology Assessment, *The Defense Technology Base, Introduction and Overview: A Special Report*, OTA-ISC-374 (GPO, 1988), p. 5. Although raiding pressures are understandably at their worst when defense budgets are shrinking, recent work by the Congressional Budget Office shows that even during the height of the Reagan-era defense spending surge the Defense Department was unable to fund many of its programs adequately. This suggests that the bow wave is large indeed and that pressures to raid technology base funds for project support are likely to operate even when defense budgets are increasing. U.S. Congress, Congressional Budget Office, *Effects of Weapons Procurement Stretch-Outs on Costs and Schedules* (CBO, 1987), pp. 9–10.

49. Commission on Integrated Long-Term Strategy, *Discriminate Deterrence* (GPO, 1988), p. 46.

Figure 5-1. *Defense Department R&D Obligations, 1956–87*
1982 dollars
Index, 1972 = 100




Sources: National Science Foundation, *Federal Funds for Research and Development: Detailed Historical Tables, Fiscal Years 1955–1986* (NSF, n.d.), pp. 3–18, 21–36, and *National Patterns of Science and Technology Resources, 1987*, NSF 88-305 (GPO, 1988), pp. 53–55. GNP deflators are from *Economic Report of the President, February 1988*, p. 25.

## NEW STRATEGIES FOR INVESTMENT

If defense R&D spending is now less apt to produce useful commercial returns, one way to revive commercial competitiveness would be to go back to the freewheeling, throw-money-at-it response of the 1950s. Political circumstances are not likely to permit such a reversion, however. Bureaucratization and political oversight have been growing, while reforms that run against these trends have failed. Even if reversion were politically possible, however, it would be neither technically nor financially desirable. Military technologies and the force posture they support have reached a maturity that calls for a new managerial approach tailored to the needs of national defense. This leaves commercial R&D where it belongs—on its own, deserving public support that entails managerial strategies tailored to commercial needs.



### *A New Approach to Military R&D*

The stakes involved in further developing a mature technology can be both higher and lower than they are for a new technology. They can be higher because developers can spend a great deal of money for marginal improvements in performance, and because mistakes can be costly. Holding out for another thousand pounds of thrust from a jet engine can push unit costs up far more than the improved performance is worth.[50] The stakes can be lower because no revolutionary breakthrough is likely to catapult one's adversary far ahead of one's own capabilities. Indeed, at some point it makes no sense to seek to maintain a technological advantage in mature technologies. What does make sense is to stabilize development while seeking advantage in a newer technology.

If progress is slower and more predictable in mature technologies, development need not be rushed. And if both mistakes and innovations are likely to be costly, development should not be rushed. These arguments become even more powerful when design complexity is considered. Modern systems present technical integration problems many times more difficult than the relatively simple weapons of the 1950s. Designers need freedom and flexibility near the end of the design cycle, when pieces of the system must be fitted together, as well as at its beginning. Artificially compressing the design process for complex weapon systems leads to costly retrofits or performance problems.

A final reason to adopt more judicious development is that integrating a new weapon into an existing force configuration disrupts operational routines as both line users and support organizations struggle to adapt to new technologies and capabilities. Conversely, the established complexity of the force will affect the new weapon as users encounter design problems and suggest useful changes. These interactions have become more wide-ranging and unpredictable as U.S. forces have grown more complex. Developers and military users alike thus confront an increasingly complicated force integration problem that demands time, patience, and care.

In developing new weapon systems, the military services still adopt a

50. Analysts at the Rand Corporation concluded from their study of technological change in tactical aircraft, for example, that it "has become increasingly difficult to sustain the rates of technological improvement that we have grown accustomed to in the past." William L. Stanley and Michael D. Miller, *Measuring Technological Change in Jet Fighter Aircraft*, R-2249-AF (Rand Corporation, 1979), pp. 44, 47.

crisis approach more appropriate to the 1950s. They rush systems into production and deployment on the basis of scant test data, almost guaranteeing that some development work will have to be retrofitted into production systems. This practice also ensures force disruptions and increases the cost of responding to design changes. The resulting costs are at least partly recognized, but they are accepted as the only way to remain technologically ahead of the Soviet Union. Indeed, there is widespread pressure to shorten rather than to lengthen the time required to develop new systems: "We forfeit our five-year technological lead by the time it takes us to get our technology from the laboratory into the field."[51]

In such cases the political system, in concert with the military services, moves precisely in the opposite direction from that required. In a sense, Congress and the military are operating on two premises—that shiny new hardware in the field equals effective military force and that moving quickly to full production is the best way to capture economies of scale. But new hardware will produce effective combat power only after design flaws have been addressed and forces learn to use it. And whatever savings accrue in the move to full production must be balanced against the costs of retrofitting design changes to systems in the field. The nation's security would benefit from slowing down the cycle of weapons replacement, allowing time for operational testing and design evaluation to sort out possible force integration problems before full production begins.

This recommendation sounds counterintuitive for a nation anxious to exploit its advantage in military technology. It is also out of keeping with the practice of commercial high-technology firms, which rush new products to the market in order to exploit an early technological lead, and thereafter improve the product as technological evolution and the market dictate. But the recommendation applies principally to weapon systems. The Soviets take as long to develop these as the United States, suggesting that slowing the process will not substantially threaten the U.S. lead. In any case, major system components have now matured, and the nation's technological lead rests on subsystems using new, fast-moving technologies. It is these, rather than the system as a whole, that should be modernized quickly to retain the nation's technological lead.

Yet even here commercial practice remains a poor model for the military. The military "market" is a large force resting on a complex logistics structure; modernizing even at the subsystem level is thus an

51. Blue Ribbon Commission, *Quest for Excellence*, p. 47.



immensely more costly and complicated process for the Defense Department than it is for most businesses. Additionally, the military's market test is not everyday use but war. If war is not very likely, it makes little sense to buy a new, high-technology component in quantity, since technological change will quickly make the component obsolete. Conversely, if war is likely, the organizational perturbation that often comes with wholesale modernization may actually undermine force effectiveness. In many cases it makes more sense to test new devices in a small portion of the force until they have matured somewhat, are better understood, and are changing less rapidly than to engage repeatedly and at great cost in modernizing the entire force.

Impediments to this kind of reform spring less from some enemy threat than from political and financial pressures in the U.S. acquisition process. From the earliest phases of the cold war, the rush to production has been a useful way to generate political support for a system and thus ensure its production. This suits industry as well as the military services because industry's profits have traditionally come from production more than R&D. Indeed, given the congenital optimism that marks the early stages of weapons development, defense firms usually have to fight to make profits on R&D, often accepting less than what they regard as adequate. Thus to remove some of this pressure to rush new weapons into production, the U.S. system must more fully separate design from production and provide an adequate reward for each.

Slowing the system design process will produce the desired results, however, only if designers have the flexibility to respond to problems. Thus in addition to separating design more fully from production, the design process itself must be relieved of the bureaucratic encrustation that has overtaken program management. There is no easy way to do this; much of the bureaucracy has resulted from the natural workings of the American political process. One approach, however, would be to use competition more extensively in developing near-production-ready weapons that can be operationally tested and modified in a competitive environment. This would satisfy political demands for accountability—competition is normally the only politically acceptable alternative for congressional oversight—while providing the political system with choices from among reasonably complete weapons. The divisive politics of weapons procurement would be focused on production choices rather than on the design process.

Of course, producing competing systems of this level of maturity smacks of wasteful duplication; indeed, it runs counter to the short-term perspective that dominates the nation's political process. But if the nation

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is to face the problems of the next decade squarely, even politicians will have to recognize the high price paid for the current approach to military R&D. Quality weapons—quality R&D—cannot be had on the cheap; that would be false economy. To pay more up front is to put R&D funds where they will do the most good.

Significantly, lengthening the design process could also create more reasonable choices among candidates for production. As William Kaufmann's chapter shows, this may be the only way the nation can meet its security commitments in what promises to be an era of stable or declining budgets. Reforming the way America buys weapons is thus linked directly with broader reforms in the way the nation's force posture is shaped.

## *A Strategy for the Industrial Technology Base*

If military R&D on mature technologies is less productive commercially, and if more international competition requires more efficiency and speed in commercially relevant development, how ought the nation respond? The desirable elements of a new policy are highly debatable—there is, after all, no single provably correct answer, derivable from either theory or history, as to the best organization of public support for the technology base of the economy. America should probably look at this as an area for enlightened experiment, should take what seem to be useful ideas, develop them in different ways on a small scale, and find the ones that seem to work best in the context of its economic and political institutions. We can then steer a pragmatic course, building on successes and discarding failures. While definitive guidelines for policy cannot be provided, there are some useful directions for navigating the high-technology economy of the next century.

A LEGITIMATE INTEREST OF GOVERNMENT. America must first recognize that supporting, facilitating, and organizing investments in precommercial technology—both basic science and middle-ground research—is an important function of government. The debate ought to be how best to organize this investment to build the most advanced industrial economy in the world. If building a commercial technology base is crucial, we ought not be burdened by the need to devise elaborate ruses and strategems so that other missions of government can be teased and stretched to provide the funds.

THE INEVITABILITY OF CHOICE. Public policies intended to correct for the underinvestment in research caused by problems of appropriability,



or risk and scale, ought to address the specifics of these problems. That is, public resources should be directed where appropriability problems are greatest and the risks large and indivisible. This means basic and middle-ground research, and radically innovative, or large, risky projects.

Market signals should be integral to these choices, but at the same time, since market signals miss opportunities that society nonetheless considers economically desirable, they must be supplemented by decisions that implicitly choose where to invest resources.

Some general level of subsidy, such as tax credits, to support R&D across the board may be useful (since empirical studies generally show that social returns to research exceed private returns), but subsidies cannot distinguish between projects with slight problems of appropriability and those with severe problems. In extreme cases, when no benefits can be captured for the exclusive use of a private investor, no partial subsidy can transform them into attractive, money-making propositions. And a general subsidy that makes a highly inappropriable project worthwhile does so at the cost of making much more appropriable R&D projects excessively attractive. Thus, while some type of general R&D tax credit would seem useful, it should be supplemented by policies targeting research and radical, high-risk projects whose returns are much more difficult than average to capture.

NEW INSTITUTIONS. Funneling support for precommercial middle-ground research through existing institutions is subject to Bush's law. Administered through so-called mission federal agencies, such support inevitably competes with more applied, mission-related projects, and presumably suffers in battles over scarce R&D dollars within the agencies. One might argue for adding these objectives to the National Science Foundation's mandate, but imposing criteria of long-term economic and commercial relevance on choices would conflict with the NSF's historical mandate to divorce basic research funding from commercial tests of any sort.

What is needed is a separate institution, with its own new and important mission: to protect support for economically significant middle-ground R&D projects from the ravages of Bush's law. If the budget for these sorts of projects is to be altered, let it be by explicit congressional or executive mandate, not by budget wars within agencies with only a peripheral interest in the health of the commercial technology base.

Bush himself may have summed it up best when he described "two basic principles for successful government participation in scientific research. First, the research organization must have direct access to

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Congress for its funds; second, the work of the research organization must not be subject to control or direction from any operating organization whose responsibilities are not exclusively those of research."[52] We would add to Bush's formula only the suggestion that identical principles be applied to federal support for commercially relevant, middle-ground research and the thought that differences in objectives and orientation make a distinct organization responsible for funding the middle ground as necessary as one responsible for basic research.

INDUSTRIAL RELEVANCE ON THE AGENDA. Industrialists are certainly in closer contact with the market than bureaucrats and may have valuable insights into what technologies are potentially of greatest commercial importance. Industry must therefore be allowed a significant voice in setting the agenda for supporting research intended to strengthen the commercial technology base. Rather than allowing the Pentagon or any other government agency to devise plans and issue directives, a separate government institution should serve as a contact point, facilitator, collector of information and scanner on the world horizon, to which industry would come with proposals. Such an organization might even distribute reports and proposals to industry for comment and possible expressions of private-sector interest.

The projects selected should always be designed to benefit the technology base of an *industry*, however, not an individual firm or group of firms. And the projects should not be a sophisticated form of pork barrel. Public resources should be invested only if industry is willing at least to match the funding. Sharing costs and risks creates incentives for allocating resources efficiently. Funds should flow only into projects industry believes are productive, ones in which it is willing to sink its own resources, but where benefits are difficult to capture privately and individual efforts unlikely to succeed.

DIVERSITY IN DECISIONMAKING. Federal agencies sponsoring R&D have rarely seen eye-to-eye on what was and was not worth funding. Development of the original mammoth computers—ENIAC, Whirlwind, ILLIAC—was often fiercely opposed by one set of potential funders, staunchly supported by another. Money was perhaps wasted on some dead ends, but other projects paid off many times over. The point is that no one is omniscient, and diversity—parallel approaches—is worth

52. Testimony of Vannevar Bush, "Research and Development," Hearings, House Committee on Military Affairs, 79 Cong. 1 sess. (GPO, 1945), pp. 4–5.



maintaining. The United States would be much poorer technologically if some single funding authority had been granted an exclusive franchise to decide research priorities. It would be a mistake, therefore, to create some superagency to reign as undisputed czar over the government's nonmilitary technology investments. Each agency has its own mission and ought to be encouraged to invest in technological innovation when it provides a solution to a particular problem. What is needed is a federal entity focused specifically on the commercial technology base, an ombudsman for industry and an advocate for policy. A strong nimble organization to speak up for commercially relevant technology, to facilitate proposals by industry, and to work to couple academia and commerce would provide a new dimension to public debate.

ADVANTAGES OF COUPLING AND COOPERATION. One lesson that emerges from the history of both computers and superconductors is the advantage of collaboration in research among universities, federal laboratories, and industry. Coupling between the universities and industry played a major if sometimes inadvertent role in developing the first computers. The university computer projects strongly influenced the technical designs of products that emerged in the 1950s, though the mechanism for transfering technology was often people who left academic projects and joined industrial laboratories. In the 1950s and 1960s such large military projects as the SAGE bomber defense system, Project MAC (computer timesharing), or the ILLIAC IV supercomputer often teamed university-based researchers and industry. This coupling provided a continuing conduit between the basic research undertaken in universities and the industrial laboratories working on concrete applications, and it directed the basic researchers to interesting problems with direct relevance to useful applications.

These projects were also characterized by considerable cooperation and sharing of knowledge among the industrial contractors that teamed up on them. SAGE, for example, brought together IBM, Burroughs Corporation, RCA, General Electric, the System Development Corporation (SDC), the Bell Labs, and MIT. Project MAC included General Electric (and later, Honeywell Corporation), MIT, and the Bell Labs. ILLIAC IV involved Burroughs, Fairchild Industries, Texas Instruments, and the University of Illinois. Part of the successes achieved included diffusion of the common knowledge and experience accumulated on the job to a wide cross section of the industry.

Private firms may also duplicate precompetitive applied research as they develop commercial products. Such duplicated effort cannot be

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easily translated into a competitive advantage and will reduce the overall return on the industry's investments in R&D. Reducing duplication and underinvestment in more basic research can be a powerful motive for experimenting with cooperative research ventures.[53]

It is worth remarking that the Japanese have made cooperative research programs, jointly pooling private and public funding, the focus of public support for R&D. By sharing knowledge and eliminating unnecessary duplication, they have economized on resources invested in more basic, precompetitive areas of research and appear to have derived significant industrial payoffs from relatively modest sums of public funding. Sharing also encourages private firms to combine resources on research for which risks and potential returns are great but the possibility that any single firm will capture the bulk of the return appears modest. Their approach has been very much one of flexibility and pragmatism, experimentation and pursuit of avenues that have proved productive. Their continued use of this model suggests that all parties consider it a solid and useful investment.

WORKING FOR AN OPEN INTERNATIONAL SYSTEM. As long as the economic future of the United States continues to be linked to high technology, it must support an open global economy. U.S. high-technology industries have always sought the widest possible market to earn the best possible return on relatively fixed R&D investments. If the United States responds to apparent provocations of others by erecting protectionist barriers around its markets, it will undermine the principle of an open system. In the long run protection will strangle the returns, slow investments, and stunt growth. Clearly, America should instead seek to strengthen the principle of open markets, to knock down barriers, not reinforce them.

It is unproductive to suggest that foreign governments should be prevented from subsidizing R&D intended to benefit their countries' firms commercially, since essentially all governments—loudly and openly or quietly and covertly—do so. One might, however, suggest that all would benefit (through reducing duplication, for example) by making reciprocal participation in such national R&D programs a matter of bilateral negotiation.

53. See Michael L. Katz, "An Analysis of Cooperative Research and Development," *Rand Journal of Economics*, vol. 17 (Winter 1986), pp. 527–43; and Michael Spence, "Cost Reduction, Competition, and Industry Performance," *Econometrica*, vol. 52 (January 1984), pp. 101–21.



On the other hand, the relatively heavy U.S. investment in basic research has the character of an international public good in today's world of rapid, inexpensive, and essentially uncontrollable scientific communication. When such basic science was mainly commercialized by American firms, this investment was no burden. But in a world of technological peers who are just as likely to commercialize products that draw on advances in technology, it is appropriate to internationalize some of this expenditure as well, to ask that others spend to replenish the common pool in rough proportion to their withdrawals. Foreign countries may have to increase contributions to U.S. basic research programs and to do more research themselves. To some extent, this is already occurring—in Japan, for example—and should be further encouraged.

To conclude, the United States in the 1980s faces the maturation of its military technology and international economic competition with technological peers. On the military side, measured and careful investment driven by mission and requirement is the appropriate response to shrinking budgets and diminishing returns to investments in technology. On the economic side, the United States should ask other nations to support a commensurately larger share of the burden of investing in the least appropriable basic research, and should move to help firms earn returns on technology investments. This in turn means it must recognize the government's role in maintaining the industrial technology base. New policies must be designed to help American firms commercialize products that draw on American advances in science and technology. Effectiveness and efficiency must become hallmarks of the R&D investments intended to benefit the economy of tomorrow.

The world has changed, but America has not. Can we face our challenges from a position of strength, in full command of our extraordinary resources, or will we ignore them until forced into full retreat, in crisis, with our strength diminished? These problems are now evident to many in our society, and a new consensus can emerge. The time to restructure is now.

Mr. WALGREN. Thank you, Dr. Flamm. We appreciate that.

Well, somehow, in the effort to define what might be proper or what's not proper and what might be basic or what might be middle, it strikes me as hard to define.

I guess I'd like to ask the other panelists if they wouldn't respond to the thought that Mr. Buechner raised about:

What is middle ground versus more basic?

The thing that comes to my mind is the Supreme Court's definition of pornography, which essentially was:

You can't define it, but you know it when you see it.

I wonder, are we in that kind of an area where we really can't define where the line is, but some things should make sense to us? And some things may not make sense to us?

I suppose that's really a copout of trying to provide direction. And we have to do better than that.

Can the other panelists respond to Mr. Buechner?

Dr. BEMENT. I'll attempt to respond.

I think one of the elements is timing. For example, when the market is defined and is well-understood, it's at that time that the window has passed, I think, for government participation in trying to get involved in new market developments.

I think the ATP opportunity is really to anticipate new markets and to reduce technological risk prior to the market being established.

In that respect, in many cases, it's not just the technical knowledge or the factual knowledge that's important, it's also the procedural knowledge that industry has, the know-how of how to take new technical concepts and adapt them to a commercial opportunity.

In many cases, that gets to be a very messy process. It doesn't follow the usual paradigm of science begetting new technology, begetting new commercial products. In many cases, it works the other way around:

The market demanding a product and that product suggesting ways in which to satisfy the market needs.

I think, furthermore, in our society, we have for the most part addressed most of our societal needs and a lot of new technology, emerging technology, is addressing societal wants.

But, oftentimes, what happens is that, when you satisfy the wants, that want leads to a need. For example, we developed the personal computers with the idea of having something in the home that would facilitate home use of personal computers and that market developed rather slowly.

But then, when it became rather obvious that desk-top computers would be tremendous productivity aids in industry, suddenly, a whole market emerged and flowered that now addresses an industry want.

So, a want eventually evolves to a need.

The usually macroeconomic concern, I think, of an ATP approach is more or less:

Let the market determine the winners and losers.

But, if the market doesn't exist yet, if you haven't anticipated the market, then it's very difficult to use that approach. So I see it in a technological world, where technology is accelerating faster

and faster, in order to improve our chance of having a better position in these emerging technologies, putting the investment well in advance of the market being established, in order to have an established position which industry can then exploit once the technological risks have been sufficiently reduced.

Mr. WALGREN. Mr. Heaton.

Mr. HEATON. Maybe I'm taking somewhat of a different approach. But I don't think it's particularly necessary to worry about what is basic middle applied and commercial. In my view, what we need is a process to make the relationship between government and industry SOP, or standard operating procedure for industry.

That is one of the bottom line lessons, I take it, from the foreign experience. In Japan and Germany, for example, there are programs that industry goes to routinely to talk about promising new initiatives. These initiatives are a few types. There are times when industry is unlikely to fund something on its own, but when it's clearly meritorious—for example, when you have generic research, that is, research that nobody can own, few people fund it.

When you have very large-scale research objectives that single firms, or even a few firms in combination can't fund, that doesn't get done. And sometimes there may be no forum in which to share information which can be beneficial to everybody and which has not been passed around.

Those are the kinds of things that the government should support. I don't think we need to focus on particular industries and be too careful in our definitions.

Again, what I think we need is a process. We can leave the decisions about what is worthwhile technically to the industry and highly trained technical people in the government agency.

So I would focus on process, not definition.

Mr. WALGREN. I wonder if there's anything—there's a children's book that's read often now about a structure that's looking for a missing piece. It rolls along and it's got this gap in it and it bumps and it stops and it can't go forward until it tries adjusting a couple of pieces that don't fit that configuration.

That doesn't work and then, ultimately, it comes across just the right piece. Then it's a whole circle and it just rolls at that point.

I wonder if there's some way of looking at this as to what is missing and can we see in the history of American industry where they don't do the research or development needs to be done. And could that be defined as a missing piece that could be provided somehow?

Mr. HEATON. Exactly. I would think ATP is the place where one goes to look for missing pieces, and design those missing pieces, if necessary. You might say, for example, if you take high-definition television today, there are people doing all sorts of things. There are many competing technologies. There are all kinds of flowers blooming in that garden, and we don't know which piece is going to fit where yet.

It seems to me that's the kind of situation ATP could usefully come into.

Mr. WALGREN. Mr. Flamm.

Dr. FLAMM. I guess the point I wanted to make was inevitably one ends up talking about definitions. You say, well, we're going to fund generic research. Then you have to talk about what's generic.

Or, you say, we're going to fund very large-scale projects. Then you get into a discussion of what a very large-scale project is.

And at what point you draw the line, it's inevitably, it's impossible not to talk about what general kinds of projects are the purview of government. And there's broad agreement that at the very applied development, commercial exploitation end of the scale, that is not a place for government to get involved. There's broad agreement that at the basic research end, that is a place where government is already involved and the National Science Foundation is awarding it on that very basis.

Mr. WALGREN. Let me ask this. Is the reason because there is not an incentive for the business to do it? Not that—I mean, is that the fundamental lack?

Does that mean that if you can define areas where something should happen but there's no incentive essentially to do it that that then should open the gate and legitimize the effort?

Dr. FLAMM. There's a very clear argument for government support for research and development. Unfortunately, making that clear argument into an operationally relevant definition is not a particularly productive enterprise.

The clear argument is this:

There are certain types of research projects, for example, where you expect the outcome of that research project to not be able to be cleanly captured by the firm that undertakes the investment.

That's a typical argument for basic research. If you are successful in proving or disproving some fundamental idea, it's very difficult for you to capture ownership over the result of that exercise. Others can use their idea. It's difficult for you to appropriate and capture.

Mr. WALGREN. Therefore, there's no incentive for you to do it.

Dr. FLAMM. Exactly right. Or not necessarily that you can't capture any at all, but you can't capture the full benefit. And, therefore, a gap opens up between the private return to undertaking that project and the social return from society's viewpoint as a whole.

And that is one of the fundamental arguments for government support for research and development.

The other has to do with what George is talking about—scale and risk for very large projects which are beyond the scope of a single firm.

Unfortunately, you may ask the question, are there any clear guidelines as to what kinds of research projects? Is there any clear guidance on when you can appropriate and when you can't appropriate?

There are some generic ideas that is, within general, for commercial development within a firm of an actual product that's going to market. The thinking is that that's actually much easier to appropriate, to capture for your own benefit, than for very basic research.

But, really, that's as far as the argument extends in giving you clear guidance.

So my point was going to be that I think the best way to approach it is to say: What kind of things do you not want to do? Because perhaps you can be a little clearer about that. You don't

want to develop actual prototype commercial products that are to be manufactured. You don't want to invest in production facilities.

I mean, that is something that I think Dr. Bement was referring to. That is the normal purview of the private firm.

Perhaps it's easier to draw these kinds of lines by illuminating activities you don't want to undertake than restricting yourself to a certain class of activities that you do want.

Mr. WALGREN. My time is expired. I'd like to recognize the gentleman from California, Mr. Campbell.

Mr. CAMPBELL. Thank you, Mr. Chairman.

Mr. Heaton, your caution about professors and lawyers is sound. I wanted to ask you though, from your expertise in comparing the European systems, particularly on the antitrust side—I don't know if you've had occasion to look at a bill that I and Congressman Boucher introduced—H.R. 1024—but if you have not, it creates an antitrust exemption for American firms that wish to collaborate, taking joint research and development down into manufacturing and commercializing it.

From your comparative point of view, I wonder if you could tell us what Bundes Kappelle Amt and the JFTC attitudes are toward joint research/development and commercializing under the German and Japanese antitrust regimes respectively.

Mr. HEATON. I have spent a great deal of time talking to the people of the JFTC in Japan; the Germans I know much less about.

The Japanese simply don't see this as a problem. They think there are things you have to guard against, such as deliberate exclusion of some people from the cartel. And they think these are fairly easy to get at because they have a scrutiny procedure which is actually considerably stricter than ours.

They sit down with the members of a research consortium, look at their plan, discuss it in a great amount of detail and they get informal advice.

The proposers from industry routinely take that advice. Because of that process there has never been a negative ruling on a research consortium.

I think that the premise behind your bill that we should extend some kind of antitrust exemption to things that go beyond research is a very good one for several reasons.

One is the difficulty of distinguishing between research and other things. So, if we don't have that kind of exemption, we are creating what I think are artificial conceptual barriers. These are likely to maybe deter people from entering into joint research in the first place and certainly deter them from commercializing.

So it may frustrate the very thing that we're trying to accomplish when we set up the first antitrust exemption.

So I think it's a very good idea. I think the risks to the extent they are there can be controlled successfully.

Mr. CAMPBELL. I'd like to address my second and last question, Mr. Chairman, to the other two panelists. It also deals with the bringing of research and development into the commercial area, manufacturing and commercializing.

Dr. Flamm particularly made a comment about the difficulty of expropriating all of the value of research and development and, hence, a disincentive to engaging in it.

Dr. Bement, I take it at TRW you have had some experience with commercializing research and development. I'd like to put forward the following theory, and if you could tell me whether it is accurate or not from your experience, I'd be grateful.

The theory is that: If you do not allow research and development to go down into manufacturing and commercializing, what you lose is the lessons that can be learned from dealing with customers.

And, secondly, if you allow research and development consortia but now taking it into the next step to manufacturing and commercializing it, you create perverse incentives for their investment in research and development; namely, the incentive to withhold your very best ideas lest your very best ideas be exploited by someone; whereas, if the consortium is allowed to develop it, the profits will be shared.

Well, that's a theory and I wonder if it comports with your practice—either of the two gentlemen.

Dr. BEMENT. The Chairman talked a few moments ago about industrial incentive to commercialize a new technology. That incentive, by and large, is pretty much a balance between opportunity and risk.

A lot of what R&D attempts to do is to build up the opportunity side of that equation. In many cases, to address the risk part of it, one does have to get much more involved in downstream activities.

One way to build incentive is to either improve the opportunity or reduce the risk and it's in this area that I think the ATP program would be very helpful.

Also, the antitrust exemption that you're talking about, because it's not just the intrinsic value of the technology itself, it's how well can it be adopted and how well can it be integrated with production, with other types of processes, customer support, warranty and liability issues and these types of issues.

In many cases, the very same companies that might be the ideal companies to exploit the technology oftentimes refrain from doing so because the risk is too high. And in many cases, by sharing that risk within the industry, until one understands the technology and the risk has gotten below a certain threshold, then industry can take over and commercially exploit it and reduce that leadtime, which is what you really want to do—get the leadtime down to as short a time as possible.

Dr. FLAMM. I have to confess I'm a little bit more skeptical about the proposal for some kind of blanket antitrust exemption on joint production by companies than perhaps George is. Let me tell you why.

First of all, I don't think a demonstrated need for such an exemption, the case really hasn't been made. You propose an argument which is sort of a theoretical argument, but I haven't seen any body of data or examples. Right now, firms can, in fact, undertake joint ventures without antitrust exemption if they wish to do so. And joint ventures of course are common throughout industry in commercializing technology and products.

So I would ask firstly what is the pressing need for such a body of legislation?

And you can make a good case for government involvement in R&D.

I think the case is less clear because there's a downside to collusion between companies, and that is the potential for collusive activity on the part of this company which extends beyond the punitive purpose of the measure.

That introduces a requirement for measurement control and observation, et cetera.

So I'd just ask you to think about that.

The second point I think is that I don't think the Japanese model in terms of the operation of the Japan Fair Trade Commission is not the best model in the world in terms of a vigorous enforcement of antitrust.

The Japanese economy is rife, I would argue, with things like cartels, legal and illegal, collusion among firms and standards of business behavior that would be considered anticompetitive in the United States.

So, when George holds up the Japan Fair Trade Commission as a model, I would ask:

Is that really the model, the path that we want to go down?

Finally, if you ask the question, "How is it that we can get ideas out of these research and development consortia into commercial products and production if we're not allowed to extend the consortia exemption into production?" I would say that the history of research and development consortia—and, here, the most vigorous example again is Japan—is that you don't necessarily require collaboration to continue through the production stage.

In Japan, for example, in the areas of computers and electronics, where I'm familiar with the very successful consortia that are operated by MITI, the typical vehicle for technology transfer is that firms sent their people to function, to work in the consortia.

They then leave taking that knowledge with them. Those ideas and prototypes are then exploited by individual firms and commercialized in the context of the specific market.

The vehicle of technology transfer is people. Technology is in people's heads. If you can get your people on the inside where the idea is being developed, then they are the vehicle for transmitting the technology downstream to the commercial industry.

So I would urge caution on the score of the blanket exemption for joint production.

Mr. CAMPBELL. Thank you, Mr. Chairman.

Mr. WALGREN. The gentleman from California, Mr. Brown.

Mr. BROWN. Thank you very much, Mr. Chairman. I appreciate very much the views that have been expressed by the panel. I'm surprised that there is such seeming unanimity that in our wisdom we have created a vehicle here in the advanced technology program that might even work.

Dr. Bement, you probably are the closest to the operations over there at NIST.

Do you think that the mechanism there really can provide for the interaction with industry at the appropriate levels to develop a policy and make selections as to specific technologies that can provide a contribution to our global competitiveness?

Dr. BEMENT. I think, from an implementation point of view, there's probably no agency in the government better equipped to interface with industry on a working basis.

Mr. BROWN. That's pretty faint praise.

Dr. BEMENT. I think, in terms of policy and playing the convener role and trying to set a national agenda, that does go beyond what I would perceive to be the strong capability.

Mr. BROWN. It would be done at the level of the Under Secretary?

Dr. BEMENT. I think it should be done at the level of the Under Secretary.

Mr. BROWN. Is that high enough?

Dr. BEMENT. I think it is high enough. I think it is consistent with the role of the Under Secretary. Obviously, it would have to involve strong inter-agency participation.

Mr. BROWN. You see, we don't have an Under Secretary at present, do we?

Dr. BEMENT. We have an Under Secretary for Technology in the form of Dr. Ambler.

Mr. BROWN. The Subcommittee and the full Committee have been grappling with this problem for longer than 10 years. I think it goes back at least to the time when we wrote up the Science and Technology Policy Act. Then, the Stevenson-Wydler Act and the Cooperative Research legislation.

And, again, I think we're all pleased to have you indicate that this infrastructure is moving in the right direction. But, as you also are aware, it has never been accepted and funded, including the Office of Science and Technology Advisor.

And I'm inclined to feel that the problem still is the one defined by Mr. Flamm on page 4, where he says:

> The very first thing we must do is explicitly recognize that supporting, facilitating and organizing investments in pre-commercial technology is an important function of government in the high-technology economy of the coming decade.

We don't like to do that. The progress we've made, SEMATECH, for example, was not justified on that ground, but on defense grounds. The efforts that we've been making in the National Science Foundation to set up consortia to approach these problems has been justified on the support of basic research function, not the pre-technology function.

In fact, it was a rather dubious activity for NSF to begin with. There is no acceptance of this and it is the largest single problem that faces us, in my opinion, even though we've been fighting it for 10 years.

How do we win that fight?

Dr. BEMENT. Well, I think there clearly is room for healthy skepticism in this area. You've got to remember the potential pitfalls, but I think the time-scale of technological development has now become shorter than the time-scale in government to make judgments on some of these issues.

I think therein lies a reluctance to move ahead aggressively. But I think the time has come for some degree of risk-taking and also some patience, because how one deals with industry, recognizing that for so many years there's been an adversarial relationship between government and industry, how one patches that up and brings industry and government together again, how the Federal Government is going to leverage off initiatives within the State

governments, how you're going to develop quadrilateral relationships between States, the Federal Government, industry and academia.

We are now only beginning to experiment with some of those models. And I think it's going to be a while yet before we're going to have a clear judgment on how well those models are going to work.

Mr. BROWN. Well, it's been our view that this is an important change to create this support which you've described here. And it would take a little time. I don't think any of us thought it would take a generation.

Mr. WALGREN. Would the gentleman yield?

Mr. BROWN. Yes.

Mr. WALGREN. I've been wondering, do people look at the last 40 years of technology?

In some of the testimony this morning about we're still operating on the defense side because of our history, in the immediate post-World War II era, did people look at this economy as changing in nature in a way that requires us now to recognize the legitimacy of that pre-commercial research?

Somebody was saying that you could divide the economic prospects of the United States and at some point in the 1960s, things changed from an economy that got its wealth out of, number one, exporting oil?

I was stunned to realize that the United States was the major exporter of oil in the 1950s. I'd never realized that, that we had great wealth stemming from the export of agriculture that is now in sharp competition, and that we had wealth stemming from the unique manufactured products, which are now no longer unique.

I guess my question is: If we look at our economy, can we really see the need of doing this pre-commercial research now? Then, it was not necessary to have a wealthy economy in the fifties, where we were the world's greatest exporter of natural resources and had a unique manufacturing capability in airplanes, power plants and some of the highly manufactured goods that the rest of the world was not involved in.

Dr. BEMENT. I think, if one looks at the fifties, and even the sixties, we dominated most fields of basic and applied research in the world. Since that time, there's been considerable technological leveling in the world in the sense that no longer can we expect to be the first nation to make a major discovery or to be first to carry on the initial stages of technological development or innovation.

The discovery of high-temperature superconductors was essentially done in Switzerland. And you'll find more examples of that every day.

What that means is that in some instances, and the number of instances will be growing, we're going to have to be the fast follower. We're not going to be the initial developer, which means that to become a fast follower, you have to be prepared. You have to have capabilities in place. You have to have the infrastructure in place. You have to operate more in an exploitive mode because of the very short time involved.

So, yes, I think the situation has changed dramatically in the last two decades. We're seeing that almost daily.

Mr. WALGREN. I appreciate the time.

Mr. BROWN. I'm going to pose just one additional question to you, gentlemen.

High-definition television, we have been kicking this around now. It became a buzzword last year. There are all sorts of developments. We have a High-Definition Television Caucus now. We have a High-Definition Television Task Force. We have all sorts of high-definition television stuff. And we are trying to achieve a critical mass situation in terms of agreement on what we ought to do as a nation on high-definition television.

Problem: In the industry, and those of us in Congress, frankly, we're saying, "But Congress isn't going to do anything unless the industry can get its act together," in the industry you have two main associates, the American Electronics Association and the Electronics Industry Association.

One seems to have a heavy component of Japanese corporate interests, Japanese-owned American corporate interests, and the other not. They take diametrically opposite views apparently.

Maybe I'm putting that too strongly, but they do not seem to have reached consensus yet as to whether there should be a role for the government in attacking this problem and, if so, what that role should be.

This may end up being a fairly typical situation, but one segment of American industry which is Japanese-owned or controlled or benefits from exports to Japan or whatever is going to take one point of view, and American-owned industry, which doesn't have the same interest, is going to take another point of view.

In effect, we may be prevented from reaching consensus and, therefore, in our delicately balanced political system achieving any action, because a group that is influenced by the Japanese model, the Japanese financial interest doesn't want us to follow what might be construed as the Japanese model in competing with them.

How do we face that problem?

Yes.

Dr. BEMENT. As you correctly pointed out, Mr. Brown, the numbers of industries involved in high-definition television are quite many. You've got the cable industry, the consumer electronics industry, the telecommunications industry, the computer industry, the broadcast industry, and so forth.

Mr. BROWN. A model of one consortia might not even be appropriate.

Dr. BEMENT. Each one of these industries clearly has a different strategic business plan, a different technology agenda, and I think the question is:

What is the national agenda in developing this technology?

Some would argue that we're starting out considerably behind, at least from the display side. But, when you look at what really backs up the display side in terms of an open architect receiver, which really now fuses computer capability/software capabilities with the telecommunications and hardware capability, we have the strongest industries in the world. We have the strongest technology and the strongest opportunity to integrate this into high-definition television industry if we can get our agenda together.

So I think the main issue there, and this is a test of what value the Under Secretary of Technology can provide in a case like this, is to play the convener role, bring the industrial interests together and try to determine what that national agenda should be.

If he can succeed in doing that, then, clearly, that would be a test of the power of his position.

Mr. BROWN. That's why I brought up the question of the level at which policy or action would take place with regard to advanced technology, because just this one little, old dinky technology, high-definition television, really involves a broad scope of the American economy. And the policy decisions made in many ways involve the future of this country. It shouldn't be made at the level of head of NIST.

Maybe the Under Secretary, more likely the Secretary, but probably with the Executive Office of the President being involved through the National Science Policy Adviser.

Dr. BEMENT. I agree with that.

Mr. HEATON. Clearly, this is an area of great importance to the future of the country. As has been pointed out, it has a very broad impact on many different industries and there are also a multiplicity of approaches suggested.

I think we have to remember that we have no crystal ball. We don't know what the outcome is going to be. This is typical of many technical revolutions. We don't know what the outcome is going to be.

What I would suggest is that we need to be prepared to pounce whenever that outcome becomes a little clearer. That suggests to me then that we don't want a single, overly-focused initiative, but rather, as has been suggested, maybe a variety of consortia.

It seems to me that is one of the assumptions implicit in the ATP which I agree with, that the usual case should be rather small-scale endeavors. There is a 2 million, 3-year trigger which asks for justification.

Beyond that, why not have fifteen $2 million enterprises to begin, so that we can pounce when the situation becomes clearer?

Dr. FLAMM. I actually want to second your observations. First of all, if you're talking about HDTV, it's sort of a Rohrschach blot for whatever you want to see. I think the reason you have so much involvement by so many industry groups is that everybody sees different interests involved here.

Some see the broad outlines of U.S. technology policy at stake. And they're fighting for some kind of explicit recognition along the lines you're talking about.

Some see the future salvation of the semiconductor industry at stake here. And the discussion we hear is not really about TV, it's about semiconductors. Some see the future information network of the United States and that information infrastructure, the networking that needs to be undertaken, to push us into the information age on a large scale at stake here, and see HDTV as a vehicle for pushing that agenda.

HDTV is a grab bag that means many different things to many different people. I think that's why it's provoked so much interest. However, I think it would be a mistake to categorize all those different debates going on as HDTV debates.

What they really are is about much more fundamental issues. It's a shame that we can't talk about those issues openly and explicitly. And I think that's perhaps one of the purposes of this hearing.

The second point of yours that I wanted to ratify was that I agree completely that these issues have to be addressed at the very highest level. And what we really need is something like ATP incorporated into something like the Office of the Science and Technology Advisor. At the very highest level perhaps, even, and let me make a heretical suggestion here, perhaps even taking some of the technical capacity of NIST as it's presently constituted, removing it from the Commerce Department and putting it directly at the highest level of the executive branch.

Such surgery of course requires a certain amount of acceptance on the part of the Executive Branch. So it doesn't seem like a very fruitful course for Congress to be pushing.

But I would agree completely with the thoughts you expressed.

Mr. WALGREN. The gentleman's time is expired. The chair would like to recognize the gentleman from Missouri, Mr. Buechner.

Mr. BUECHNER. Doctor, you used the word "timing". I think that's a very accurate term for us to consider. I have an investment corollary which is known as the Buechner curve. That is, when I invest in something, it's already too late for it to be moving forward—whether it was cable TV or CB radios, I remember specifically. [Laughter.]

What I worry about is that even in technology, we do get caught up in trends. We hear in Congress, and I think the gentleman from California was talking about how we've now got a caucus on HDTV, and I worry a little bit about us getting caught up in trendy things and being behind the research curve.

Does that make any sense?

I want to make sure that what steering that we're giving to this, that we're not literally pushing you back instead of pushing you forward.

How do we protect against that?

Dr. BEMENT. Just to start out in response to your question, Mr. Buechner, there's one way I put it:

The long-term is getting shorter all the time. A few years ago, we used to think of a product development cycle in terms of 3 to 5 years. More recently, it's been more in terms of 6 to 18 months.

Now that's a very short turnaround time but behind that turn around time of course is years of preparation to be able to exploit technology in order to meet those kinds of time schedules.

The point that I made earlier that the time constants of really addressing major markets and, in some cases, even inventing major markets, that invention time is oftentimes shorter than governments can respond, which means that somewhere one needs a fast response mechanism.

On the military side, on the defense side, DARPA has more or less provided that high-risk, fast start-up capability within the DoD with enough latitude and enough flexibility to take clearly high-leverage ideas and to exploit them through demonstrations or through test bed type activities and determine what the impact of what their leverage might be.

I think that if one is going to set up a program, there likewise has to be that type of flexibility and that type of institutional responsiveness so that the technical program leaders will have enough latitude and that those policymakers that they report to will have enough patience to operate on those types of time constants.

Otherwise, I think it's not going to be very effective, and I don't think it will make much of an impact.

Mr. BUECHNER. Mr. Heaton, do you have a comment on that?

Mr. HEATON. I want to say something about Japan which I think is relevant to this discussion.

The Japanese have a reputation for picking winners, which I think is partly undeserved. They have picked winners, but there have also been a number of losers that they've picked.

But the reputation for picking winners comes from the typical historical way in which MITI has operated, which is to focus some of its resources on designated sectors. They now are realizing that there are trends, as you put it, and the faddish technologies and the long-term has become shorter, and that it is going to be impossible for people sitting in government to make the kinds of decisions they did in the past.

What the Key Technologies Program represents, which would be the major technology support program in the future, is the decision to let industry set that technical agenda and have the government respond when there seems to be a good proposal, without deciding a priori in which sectors they will put their money.

Mr. BUECHNER. Mr. Flamm, give me your opinion. Has SEMATECH been a successful venture?

Dr. FLAMM. I think it's barely got going. It's a bit premature to pass judgment.

Mr. BUECHNER. Do you like what you see so far?

Dr. FLAMM. I think the basic idea—I think there's a lot of good things about SEMATECH. There are some potential downsides. I think the good thing is rather than sort of turning to restrictive trade policy as a remedy for the problems of the semiconductor industry, SEMATECH recognizes that there is a technology problem that needs to be addressed and attacks the structural problem in a fairly direct way.

And I think that is an excellent idea. I'm glad it's around. And I hope they do good things.

As to the technical directions it's going in, I'm not really qualified to judge on that. I do know that the person who is directing SEMATECH at this moment, Dr. Noyce, is an excellent respected figure who is just now beginning to set his mark in terms of the agenda of SEMATECH, and I hope he does good things.

I think maybe in the long genesis of SEMATECH that's something to be desired, but it's underway now and I think we ought to support it.

Mr. BUECHNER. One last question, Mr. Chairman. I guess it's the inevitable question, and that is funding. I'd like you each, without having to justify it in any way or to say where it would come from, taken from whatever other program or what ducks we have to quack to get it, give me an idea of how much money you think we ought to be putting into this program.

Dr. Bement, do you want to go first?

Dr. BEMENT. Well, I included in my testimony the notion that each of these efforts have to be funded to a sufficient level to make the desired progress. So, obviously, this will probably vary considerably depending on how many technology thrusts that you want to pursue and what the nature of those thrusts is.

But I think, in order to at least bracket the question of cost, many of these technological thrusts will probably have to be funded at tens of millions of dollars per technology thrust per year, in that order of magnitude.

And on top of that, we'll have to be very highly leveraged by the industry investment. That leverage factor might be anywhere from two to five.

To put together the necessary resource to keep it from dissipating and getting highly fragmented and also to sustain it; if it's not going to be sustainable over the time necessary to make the desired progress and the desired impact, then that, too, will dissipate the effort. It won't be cost effective.

Mr. BUECHNER. Mr. Heaton.

Mr. HEATON. If we look at the experience under the National Cooperative Research Act, which provided some antitrust exemptions and procedures for research consortia, we see that there have been on the order of 10 or so per year that have sprung up since the end of 1985. We've got about 60 now.

It seems to me this is the type of enterprise initiated by industry that it indeed might want to fund.

We talk about 10 per year times the kinds of numbers that Dr. Bement was mentioning, and you've got in the small hundreds of millions per year, which seems an appropriate target to me.

Dr. FLAMM. I just want to make one point, and that is there's enormous returns on investment in R&D. They are very productive investments. That's the lessons we've learned from economic literature which studies the returns on investments in R&D.

Let's call this the one aircraft carrier budget proposal. If we took one aircraft carrier, which is what? Twelve or fourteen billion dollars? The sums we're talking about pale in comparison to some of the hardware in the budget every year.

If we took one aircraft carrier and invested those funds in revitalizing our technology base and basic technologies, think about what that would do to the potential spillover of that kind of investment on our economy.

We certainly ought to be thinking about those magnitudes over the long term. People talk about the electronics industry and the computer industry in competition. If we spent those quantities, those kinds of sums, there's no doubt there would be a spillover.

Is that much required? I don't know.

On the other hand, what we're talking about here is peanuts, small change compared to some of the items that you folks address every day in your budget.

Mr. BUECHNER. Let me remind you that when the Navy comes around to lobby for the aircraft carrier, they always point out that on top of that gleaming new ship will be aircraft made in my Congressional District. [Laughter.]

What we're going to have to come up with is we're going to have to come up and convince people on top of whatever the new gizmo is will be a widget that's made in our District. And, unfortunately, that happens to be part of what runs this place. And that's why it's important that we give you the impetus but don't try to fine-tune it too much.

Thank you very much, sir.

Thank you, Mr. Chairman.

Mr. WALGREN. The chair recognizes the gentle woman from Maryland, Mrs. Morella.

Mrs. MORELLA. Thank you, Mr. Chairman.

In listening to what Mr. Flamm has said with regard to SEMATECH and then reading Mr. Heaton's testimony, you kind of lament, Mr. Heaton, that it seems like DoDo has the leadership in it and that perhaps it should be a civilian agency created to fulfill the intent of Congress for civilian involvement.

I wonder if you wanted to comment on that. I realize SEMATECH is relatively new and ongoing.

Mr. HEATON. The rationale advanced for SEMATECH and the rationale that's sometimes been advanced for Defense support of civilian industrial technology seems to be infinitely expandable; at some point, everything is relevant to our national security and defense.

The Defense Department, that seems to me to be a not very satisfying intellectual way to approach this.

In addition, the Defense Department may not be equipped to focus well on civilian technology and, in any event, I think it's important to have a counter-weight on the other side of the government.

Had ATP been in existence when SEMATECH was funded, I would have thought that would have been potentially an appropriate home if we could have gotten the right type of people in there.

Mrs. MORELLA. Could it still be done?

Mr. HEATON. To move SEMATECH? I certainly wouldn't do that.

Mrs. MORELLA. Not to move it, but to do more with ATP to give it that kind of authority and jurisdiction.

Mr. HEATON. I certainly think so.

Mrs. MORELLA. Mr. Flamm.

Dr. FLAMM. I just want to suggest that, as far as the technical question of moving SEMATECH from DARPA oversight to ATP or whatever, that's a trivial task because at the moment DARPA's involvement basically involves reviewing the plans presented to it by the SEMATECH leadership. It's just a question of the funding source and who has the job of oversight on the spending plans.

So that's not really a major issue. The real issue here, it seems to me, which George alluded to, is:

Are there differences between the kinds of emphases that are chosen by military and civilian or commercial technology programs?

And I think the answer is yes. You can point to very specific differences; things the military are really very interested in, which are not really all that interesting from a commercial viewpoint, gizmos that are able to take rapid temperature changes from very hot to very cold, or high bursts of radiation or whatever are not

very interesting from the viewpoint of somebody on the factory floor necessarily.

Defense is an agency with a mission and clients out in the field. Inevitably, when budget pressures come around to Defense, including DARPA, the pressure is to deliver systems that are going to do their jobs for their clients out in the field.

Now the question—are there requirements and needs of those people out in the field, our defense commanders, our military personnel, the same as the requirements and interests of commercial industry?

I think the answer quite clearly is no. Furthermore, if you look at where Defense R&D money is being spent and how it's being spent, there's been some fairly significant changes over the last couple of decades.

More and more of it is spent on developing very applied specific systems for particular initiatives. Less and less of that money in relative terms is going to research.

The amount that DoD spent on research in the late 1980s in absolute terms, in real terms adjusted for inflation, is about what it was spending in the 1970s. It hasn't risen overall.

Mrs. MORELLA. How do you strike that balance so that you have more focus on the commercial civilian facet of it?

Dr. FLAMM. Well, I think there ought to be an agency out there that has as its exclusive concern facilitating projects, government funds where necessary, that specifically look at the needs of industry and respond to initiative agenda that bubble up from industry.

And I think there's somebody who ought to be in that position. It's an important need for today's economy and it's high time we recognized it. There ought to be someone to turn to within government to respond to things like SEMATECH, HDTV, superconductivity. Go down the list.

It's not going to diminish. It's going to become more frequent. You're going to get more requests like that.

Shouldn't there be someone to turn to, some sort of agency or high level office to which people can go with those kinds of issues? I think so.

Mrs. MORELLA. That's very interesting. Maybe we should look into it further, too.

With the ATP program, should foreign-owned companies be allowed to get involved or participate, do you think, in the ATP program?

Mr. HEATON. I think they should. I think what the United States has to do at this point in time is to reach out to the technology that exists around the world. I think it is a mistake if we try to wall ourselves off from that.

It's also very difficult to define what is a U.S. company anyway. In the discussion prior to the Technology Transfer Act of 1986, I understand that this issue was addressed by the Congress and there was a decision made that we should look at activities in the United States, what takes place in the United States rather than ownership.

That seems to me a very sound way to go. I would give favor in this program to activities that occur in the United States, but if

foreigners want to bring technology and information into such consortia, I would welcome it.

Ms. MORELLA. Are there any problems? Should we put restrictions on what goes out from, let's say, even American companies to other countries?

And I note Dr. Bement also wanted to comment previously.

Mr. HEATON. I think the system of restraints we now have is adequate.

Mrs. MORELLA. You think they're adequate?

Mr. HEATON. Yes.

Dr. BEMENT. I was thinking as the panelist to my left was responding to that question I guess I wouldn't put any strictures on the program.

On the other hand, there ought to be a quid pro quo. There ought to be some criteria that a foreign company that might participate would have to meet, or a government would have to meet in order to participate, which is in the interest of fairness, reciprocity and so forth.

I think this is perhaps even a bilateral issue that might carry over into policy issues on intellectual properties and a variety of other things.

But, because there are so many joint ventures, as was pointed out, that are occurring around the globe with U.S. interests being merged with foreign interests, to address not only foreign markets but global markets, it's awfully hard to determine beforehand whether or not foreign companies should be allowed to participate.

But I think they have to earn that privilege.

Mrs. MORELLA. Thank you.

Thank's, Mr. Chairman.

Mr. WALGREN. Thank you, Mrs. Morella.

The chair recognizes the gentleman from Colorado, Mr. Skaggs.

Mr. SKAGGS. Thank you, Mr. Chairman.

I'm sorry I was not here to hear your prepared presentations this morning. Let me just follow up a little bit, if I may, on the comments and questions from Mr. Buechner earlier. A couple of statements made the point that the spinoff values from military to civilian side are more and more a question these days. And while we're not able to effect a shift of resources between the defense line and the science line in the budget, we are with our colleagues on the other subcommittees in a position to make some marginal adjustments within the budget function that we have responsibility for.

My question is: Are we making a strategic error if we continue to sacrifice the resources being put into ATP and related areas in favor of, for instance, activities like the Space Station and SSC, that either are or promise to be enormous consumers of the resources we do have some control over?

Dr. BEMENT. Let me just pass the buck. I think that is clearly a political decision, part of the political process to weigh social benefits relative to the investment and what the return on those benefits might be.

Clearly, I have my own biased point of view that I would like to see more investment go into commercial economic investment than into mega-projects, at least until we get our house in order.

Along those lines, however, I'm not going to presume to make that political judgment.

Mr. SKAGGS. But those of us who have to make it would like to make it on the basis of the best advice and information. We welcome your bias and don't constrain yourself unduly.

Dr. BEMENT. If I could just touch on another point that I think you raised in leading up to your question.

Both the Packard Commission on Defense procurement and also the Defense Science Board have both recommended that more attention be given to sourcing commercial technologies rather than to continue to invest in highly specialized defense technologies that might otherwise be met.

I think that's probably a wise policy to pursue. The question is whether it's being pursued as vigorously. Whether are the defense procurement policies that currently exist are looked at in terms of the transaction costs for small and medium-sized companies to actually be a supplier to the Defense Department, and whether we are shifting Federal investment in science and technology to facilitate that kind of a strategy, those are some of the balance points I think we ought to look at.

Mr. HEATON. I'm happy to indulge in opinion and bias. I think when you ask these questions you have to ask first what's the big problem that the country has in front of it, and, second, where are you going to get the largest return on your investments?

In my view, the big problem that the country has before it right now is the commercialization of technology and our place in the international economic marketplace. Our problem is not the wonders of science. That would suggest that we put more money in this area.

Also, if you ask where will one get a large return, there have been a lot of studies looking at what people call the social return on technological innovation. That is, the return to all of us.

And it exceeds the private returns, some say, by a factor of 30/1. That might suggest that a dollar put into commercially relevant R&D could yield 30 down the road. That seems like a pretty good rate of return to me.

Mr. SKAGGS. Thank you, Mr. Chairman.

Mr. WALGREN. Thank you.

The gentleman from New York, Mr. Boehlert.

Mr. BOEHLERT. No questions, Mr. Chairman.

Mr. WALGREN. On behalf of the Committee, I want to express our appreciation to you all. We look forward to talking with you in the future.

The second panel today, let me call forward Dr. Harold Kaufman, the vice president of research for the J.T. Baker Chemical Co.; Mr. Ian Hughes, the vice president of Inland Steel Co., testifying on behalf of the American Iron and Steel Institute; John Fluke, chairman of the board of the Fluke Manufacturing Co.; and James Berge, vice president of the Telecommunications Industry Association.

Gentlemen, we welcome you to our process. As I said at the outset, all written statements will be made part of the record. Feel free to focus on specific points to underscore them for the oral part of the record.

Let's go through the panel in the order in which I introduced you in the record. We'll start with Dr. Kaufman.

**STATEMENT OF DR. HAROLD A. KAUFMAN, VICE PRESIDENT, RESEARCH AND DEVELOPMENT, J.T. BAKER INC.**

Dr. KAUFMAN. Thank you, Mr. Chairman. I will be somewhat abstract in my longer statement.

First of all, good morning. My name is Dr. Harold Kaufman, vice president of research and development for J.T. Baker Inc. It's a position I've held for over 12 years.

I wish to thank the Subcommittee on Science, Research and Technology for inviting me here today, since it gives me the opportunity to support the chemical industry's initiative being submitted by NIST.

In the statement and CV that I provided beforehand, you can see that J.T. Baker is a long-established, highly regarded company developing chemicals with high or unique levels of purity and performance, and that I have been involved in chemical research and management for almost 30 years.

I am particularly pleased to be here because it's easier for me in a smaller company to see the many ways we at Baker benefit from the high quality scientific efforts of NIST.

I would like to ask the Committee to imagine for a moment an olympic swimming pool. Its dimensions, if you watch television, its dimensions are 50 meters by 21 meters by 1.8 meters deep and holds a half million gallons of water.

If you were to dissolve a 5-pound bag of sugar in this pool, you'd have a concentration of approximately 1 part per million.

A decade ago, reagents of this purity level were very acceptable for use in analyses and chemicals of this level were used in processes in high-tech industries.

Now, this morning, I've put a packet of sugar in my coffee. If this packet of sugar were dissolved in that olympic pool, we would get approximately 1 part per billion and its reagents with this level of low magnitude that scientists in the last year or two require for analyzing environmental pollutants and for performing high-technology processes.

In fact, now we're talking about 1 part per trillion. Now we're just talking about a few grains perhaps of that sugar dissolved in that olympic pool and these metallic impurities have to be identified and many of these metallic impurities you don't want in chemicals for some of the high-technology processing.

The ability to process such reagents and to analyze such reagents becomes very relevant to American companies maintaining world competitiveness. And it is here that NIST has become a national resource by providing technical leadership and expertise through its high-quality scientists and excellent programs, which now brings me to my objective in appearing here:

Being able to accurately detect and measure trace levels of substances is the very foundation of science and I strongly urge that NIST be kept at the forefront of measurement science and technology to leverage the competitiveness of the United States industry in world markets.

I specifically urge increased funding for the approval of budgetary increases for fiscal year 1990 and programs started in recent years, particularly the $2.1 million for chemical measurements and standards.

The benefits to be derived from funding these efforts range from major cost savings to industry, improved quality of health and environment to enhancing the competitiveness of American industry in a global economy.

The technology developed to date at NIST is facilitating more rapid commercialization of products, is being optimized by the private sector, is enhancing global competitiveness of American industry and is allowing cost savings.

In preparing my statement and summary, I had the feeling at times that some of the comments took on a sense of slogans or motherhood and apple pie. But I can assure you that the reason I am here today is because these issues have an immediacy and a relevance to me and my company.

Let me give you some examples. We have recently been working with NIST scientists in the area of high purity acid distillation. This is a project area where NIST has developed technological leadership and expertise to develop processes by which extremely high purity chemical acids, reagents, can be produced.

This week at the Pittsburgh Analytical Conference, the largest analytical show in the United States, J.T. Baker is making available to its customers a new generation of high purity acids with impurities at the levels of 1 part per billion and, in fact, we are even talking about parts per trillion.

By this action, we are rebutting current belief that the Japanese offer the highest purity acids in the world and NIST has helped us meet this challenge.

In my submitted statement, I give another example of ongoing pioneering work at NIST in the area of chromatography, which has major applications in environmental, clinical or pharmaceutical biotechnological areas; close collaboration with NIST scientists is helping us to achieve control over product reproducibility as well as to understand relations between chemical composition and product performance.

And at the same time, allowing Baker and other U.S. manufacturers to be more competitive over Japanese and European competitors.

Time does not allow me to discuss the issue of cost savings to industry, but I can assure you they are real and we in industry depend on the accuracy, objectivity and excellence of the work NIST does.

In closing, I am once again requesting that a budgetary increase of $2.1 million be approved for chemical measurements and standards.

Thank you very much.

[The prepared statement of Dr. Kaufman follows:]

STATEMENT

on

Authorization of Appropriation for the Activities of
National Institute of Science and Technology
before the
Subcommittee on Science, Research and Technology
Committee on Science, Space, and Technology
U.S. House of Representatives

My name is Dr. Harold A. Kaufman, and I am Vice President of Research and Development for J.T.Baker® Inc. I wish to thank the Subcommittee on Science, Research and Technology for inviting me here today to present my views in behalf of the Chemical Measurements Initiative being submitted by the National Institute of Standards and Technology.

I am appearing today from the perspective of the technical officer who for twelve years has had the responsibility to commercialize chemical specialties to meet the increasingly demanding needs of scientists in private, public and governmental organizations as well as the high technology industries created by their efforts.

INTRODUCTION

J.T.Baker is a well established company founded in 1904, three years after National Bureau of Standards (NIST). We are highly regarded as a company who develops chemicals with high or unique levels of purity and performance. We have prided ourselves in being able to play a leadership role for providing researchers and industry with highly characterized high purity products as exemplified by our ULTREX®, Baker Instra-Analyzed®, MOS*, CMOS* and VLSI chemicals, used in analysis, research. microelectronic processing, etc. In the 1988 Company Image Study conducted for Chemical and Engineering News, a publication arm of the American Chemical Society, J.T.Baker ranked fourth overall of 129 major United States chemical firms judged on the basis of reliability, accommodation, and progressiveness. While I do not presume to talk for the giants of the chemical industry, I feel that because of our modest size it may be easier for me to see within my own company how comprehensive and effective are NIST's activities not only on the conduct of the Research and Development function, but in nurturing products to meet ever increasing quality demands of high technology industries.

KEY POINTS

The key points that I want to highlight represent my personal experience as a benefactor of the role NIST is playing as our National Science, Engineering and Technology Laboratory as chartered by the Technology Competitiveness Act.

The Benefits to be derived from unding these efforts range from major cost savings to industry, improved quality of health and environment, to enhancing the competitiveness of American Industry in a global economy. I feel strongly that the technology developed to date at NIST:

- °Is facilitating more rapid commercialization of products.
- °Is being optimized by the private sector.
- °Is enhancing global competitiveness of American Industry.
- °Is allowing cost savings.

DISCUSSION

The ability to accurately detect and measure trace levels of substances is the foundation of all science.

NIST is the nation's central reference laboratory and many of the standard measurement methods and standard reference materials that they provide form the basis for industry to determine product quality. There is no doubt in my mind that NIST research has consistently been at the forefront of measurement science. However, without increased funding of the base programs of NIST, it will be very difficult for the U.S. to fully utilize our investment in this valuable resource to leverage the competitiveness of the U.S. in the world markets. The chemical measurement research that is carried out at NIST is vital to U.S. industry. Although virtually all industrial sectors use chemical measurements, the extraordinary transformation in measurement technology has made it impossible, from both a breadth of research and cost viewpoint, for individual companies to carry out the basic research necessary to stay at the forefront of measurement science. For these reasons a budgetary increase of $2.1 million

of Chemical Measurements and Standards is strongly endorsed.

Let me give you two examples of how chemical measurement technology, transferred from NIST, has aided product development at J.T.Baker. Recently, we had the opportunity to work with scientists at NIST in the area of high purity acid distillation, an area where NIST has developed technological leadership and expertise. They have worked on processes by which extremely high purity chemical acid reagents can be produced. The efforts to develop these processes epitomize NIST's role in assisting industry in the development of technology, to improve quality through improved processes. We at J.T.Baker Inc. have always prided ourselves in being able to set the pace for providing industry with new generations of high purity products for research. NIST has helped J.T.Baker and others in taking steps forward to advance our product lines.

A related NIST objective of considerable importance to us at J.T.Baker, is the issue of World Competitiveness! There have been numerous articles and statements made by the Japanese Chemical Industry, and repeated by American companies, that the Japanese are able to supply higher quality "Ultrapure" chemicals than available elsewhere in the world. We at Baker have contested that statement; however, the best rebuttal to combat the Japanese perpetuation of this belief, which could lead to their ultimate domination of the high purity chemical business, is for our government to provide increased support for NIST and for an American high purity chemical leader such as J.T.Baker to demonstrate that an American company can produce and market the highest quality acid reagents in the world. NIST is enabling us to meet this challenge; NIST is to be commended for the role their highly competent staff are successfully playing by implementing the goals of the NIST charter. Support of these activities by the Department of Commerce enhances our trade opportunities similar to how our global competitors in Asia and Europe are helped by their governments.

Each improvement in the area of critically needed high purity reagents requires an incremental improvement in the analytical science required to verify the purity of the materials. To date, NIST has been able to meet this challenge but the demands for analytical improvements are relentless.

NIST expertise in the improvement of detection and quantitation techniques has also helped J.T.Baker in the chromatography products area. Liquid chromatography is one of the fastest growing analytical techniques in the world. The heart of the technique is a column packed with a silica based material that is used to separate, identify and measure organic components of interest in the environmental, clinical, and biotechnological areas. In preparing these columns, there are subtle differences that affect column performance that are not well understood. As a result, seemingly similar columns from different manufacturers, or even different lots from the same manufacturer, exhibit different performance characteristics. J.T.Baker became aware of this problem several years ago, and being aware of NIST research recognized that we could utilize their work to resolve this important quality control problem.

Scientists at NIST had been working on this problem for a long time. One result of their pioneering work was the development of a three-component mixture that allows manufacturers to predict the characteristics of a specific column. By using the mixture prepared by NIST, we were able to establish a quality control process that allowed us to classify our columns into batches having similar chromatographic properties. The mixture developed at NIST should become an industry wide standard. Here too, control over product reproducibility will provide J.T.Baker and other U.S. manufacturers with a competitive opportunity in serving domestic and global markets over stiff Japanese and European competition.

It is difficult to estimate the impact of chemical measurement on the U.S. economy. However, we do know that a majority of the goods manufactured in the U.S. are, in one way or the other, affected by chemical analyses. These analyses may be on raw materials, intermediates, or final products. I am talking here about industries that combined have been estimated to make a total of about 250 million measurements a day, at a cost of about 50 billion dollars a year.

Inaccuracies in the measurement base that support U.S. industries can result in tremendous excess costs to industry. Errors occur frequently. It is estimated that between 1 and 3 measurements in 10 are repeated in analytical laboratories across this country. We are talking about 5 to 15 billion dollars in retesting costs. There is also a great need for developing new detection and quantitation techniques to help industry measure the right chemical, measure it accurately, and do it once.

The U.S. has to face a number of problems associated with the world-wide growth of analytical technology. Costs to U.S. industries have been increasing rapidly. The U.S. instrument industry already faces strong challenges from European and Japanese competitors that are sponsored, supported, or protected by government institutions. Markets for analytical instruments and supplies used in industry are expected to continue to expand rapidly for the remainder of the century. This is very important since the analytical instrument manufacturing industry is one of the few American industries that can boast a positive balance of trade. High technology industries are particularly dependent on analytical measurements as stringent requirements must be met at every step of the manufacturing process. Since no other government or private source exists to help industry, it is imperative that the funding of the chemical measurements

initiative be at a high enough level for NIST to meet these critical national needs.

As we look to the future, it is obvious that the emerging technologies are most likely to lead to innovative products and services that will allow the U.S. to remain competitive in the international marketplace. By providing early availability of the needed measurement methods and standards, NIST can make a major contribution in the race to commercialize the emerging technologies. At the same time, NIST must have the resources to continue to provide the standards and measurement services that are critically needed to support our existing industries that must retain, or in some cases, regain their competitive edge. We at J.T.Baker feel that increased support to NIST for improving chemical measurements science would be a national contribution to keeping U.S. industry competitive. This increased support will enable NIST to provide American industry with the measurement base necessary to meet the challenges of producing quality, state-of-the-art, and competitively priced products for the world marketplace. I believe an investment in this initiative will lead to more than improved chemical measurements. NIST has the potential to help us better understand the relationships between chemical composition and product performance, an understanding that is critical to the future of the American economy.

NIST expertise, leveraged with measurement technology, standards, and evaluated data, can make a difference in the U.S. position in the world economy. There are two important steps, related to the subjects I have discussed, that can help the U.S. Combat foreign domination of world markets - First, increased support for NIST will establish the critical measurement base necessary for U.S. industries to be competitive and second, American companies must take advantage of what NIST provides, and then

demonstrate as we are doing at J.T.Baker, that American companies can produce and market state-of-the-art products.

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*MOS and CMOS are trademarks of J.T.Baker Inc.

CURRICULUM VITAE

HAROLD A. KAUFMAN, Ph.D.
142 Fountain Avenue
Piscataway, New Jersey 08854

EXPERIENCE:

J.T.BAKER INC., 1976-PRESENT
Phillipsburg, New Jersey

VICE PRESIDENT, RESEARCH AND DEVELOPMENT

Member of J.T.Baker's Operating Committee. Directs group of 34 people performing basic research, feasibility scoping, development and commercial technology transfer for proprietary chemical specialties and new or improved processes for value-added products with high or unique levels of purity and performance. The Research and Development group's activities supports Laboratory products including Separation Sciences and High Purity Solvents, Microelectronics, Advanced Ceramics, and Process Chemicals businesses. The R&D group has in recent years pioneered the introduction of: VLSI™ low particulate acids and solvents for Microelectronics; PRS-1000™ and PRS-2000™ advanced positive photoresist strippers; BAKERBOND™ family of bonded phase silica gels for protein and bio-active chemical analysis, purification and isolation, including the patented ABx™ and CBX bonded phases for biotechnology applications such as monoclonal antibody purification. In addition, the ULTREX II ultra high purity acids and reagents are being introduced.

MOBIL CHEMICAL COMPANY, 1961-1976
Edison, New Jersey

MANAGER, CROP CHEMICALS RESEARCH AND DEVELOPMENT
1971-1976

Directed group of twenty-eight people in synthesis, biological screening, metabolism, field development and formulations/technical service, bringing products through primary crop registration to commercialization.

Directed development through commercialization of Mobil's first major proprietary product - MODOWN herbicide.

SECTION LEADER, PESTICIDE SYNTHESIS AND FORMULATION
1964-1971

Directed group of eighteen people in synthesis and formulation research. Initiated an herbicide program which led to the discovery of the phenoxy benzoic acid class of herbicides including MODOWN and TACKLE.

GROUP LEADER-PESTICIDE PROCESS DEVELOPMENT
1962-1963
Supervised six people in synthesis and process research of company's first active agricultural chemical development project.

SENIOR RESEARCH CHEMIST
1961-1962
Invented Mobil's first potentially important proprietary product, MOBAM insecticide. Product reached semi-commercial stage.

A.M.P., Inc. Harrisburg, Pennsylvania, 1956
RESEARCH CHEMIST

JOHN R. EVANS AND COMPANY, Camden, New Jersey, 1955
RESEARCH CHEMIST

EDUCATION:
UNIVERSITY OF PITTSBURGH
Ph.D. ORGANIC CHEMISTRY - 1961

BROOKLYN COLLEGE B.S. CHEMISTRY - 1955

PROFESSIONAL SOCIETIES:
AMERICAN CHEMICAL SOCIETY
BRITISH CHEMICAL SOCIETY
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
SIGMA XI
PHI LAMBDA UPSILON

ACTIVITIES:
GORDON RESEARCH CONFERENCE IN AGRICULTURAL SCIENCE - 1976 VICE CHAIRMAN AND 1978 CHAIRMAN
MIDDLESEX COUNTY COMMITTEEMAN
STATE OF NEW JERSEY SCIENCE ADVISORY PANEL
MEMBER PISCATAWAY CULTURAL ARTS COMMISSION
AMERICAN CHEMICAL SOCIETY AWARDS COMMITTEE
CHAIRMAN J.T.BAKER INC. NOBEL LAUREATE SIGNATURE AWARD LECTURE COMMITTEE

OTHER LISTINGS:
AMERICAN MEN OF SCIENCE
WHO'S WHO IN THE EAST

INVENTOR IN OVER TWO DOZEN UNITED STATES PATENTS.

Mr. WALGREN. Thank you, Dr. Kaufman.
Let's turn to Mr. Hughes.

**STATEMENT OF IAN F. HUGHES, VICE PRESIDENT, RESEARCH AND QUALITY, INLAND STEEL INDUSTRIES, INC. ON BEHALF OF THE AMERICAN IRON AND STEEL INSTITUTE**

Mr. HUGHES. Good morning, Mr. Chairman, Committee members. I am Ian Hughes, vice president of technology for Inland Steel, speaking on behalf of the American Iron and Steel Institute, whose member companies account for approximately 80 percent of the raw steel produced in the United States.

I would like to talk through the testimony and explain the fit that the steel industry has and NIST. We've been producing iron and steel in roughly the same manner for approximately 4,000 years. And in looking ahead, how we can obtain a quantum difference between that methodology and the rest of the world, we set ourselves the sights of:

What would a visionary steel mill for the 21st century look like?

Basically, the objective of a steel part is to plant. It's to take iron ore and convert it into a customer's product in the most efficient manner. We would like the new steel plant to be environmentally benign so that any community in the United States would wish to have it as a good neighbor.

We compared that vision to the current state and the current state of steel technology is that we have a wide variety of processes that are required to take that iron ore and convert it into a final product.

If we could consolidate those into much more simple theories of processes, we could achieve that overall objective.

At a recent meeting in which we tried to analyze the best method of doing that, we concluded that we could consolidate them into three—the conversion of iron ore into steel, the conversion of liquid steel into a thin strip, and then through intelligence processing, the conversion of that thin strip into the final product requirements of the customer.

The first process which would allow us to get away from the dependence on coke, which has environmental difficulties, is already the subject of a national project under the auspices of DOE, direct steelmaking.

The second type of process, thin strip casting, is technologically extremely difficult. It was first thought of by Bessemer in 1850 and no one has been able to consolidate the technology to make it work. And there are currently fragmented processes being individually pursued by different companies in the United States.

The task of that second activity is to consolidate those to choose a process and move ahead in similar form to direct steel-making. Having achieved a thin strip, converting that into the final product through intelligent processing, is really where I would like to focus the remainder of my discussion, because that is where the fit with NIST really is developed.

We need measurements that will allow us to control the process satisfactorily. The measurements that we require vary from temperature and vibration to the actual measurement of physical prop-

erties. And there's probably no better establishment in the measurement field than NIST.

To give you a specific example of how we envisage this 21st century intelligent processing unit, we would be taking the thin strip and in one complete process pickling, tandem rolling, annealing temper rolling and inspecting it.

In that type of process there's about 5 miles of steel, so the integrity of the process is absolutely important because fishing out a broken coil is very difficult.

The key to that is to have sensors which allow you to know exactly what is happening with respect to temperature and the properties.

That in turn would be fed back through process models and controls, so we would have 100 percent reliable process.

Unfortunately, we sell the steel to customers to meet specific requirements. For example, mechanical properties such as strength and ductility. We have no process currently in place which allows us to measure those particular parameters directly.

So, one thing we would envisage, that would give us a quantum breakthrough; certainly over any technology that we know that is currently available anyway would be a sensing device to directly measure mechanical properties.

Currently, we have to stop the process, take steel out, cut pieces out of it and pull it mechanically.

We know of no particular physics that would allow us to do that, so it's a real intellectual challenge. If we were able to do that, the increase in information that could be fed back into the process would be phenomenal.

It would also be fed directly through electronic transfer to customers, which is again today something which is currently not available.

So, basically, we see this quantum jump that the steel industry requires and is outside the realm of our expertise to the very direct fit with NIST and we really urge funding to be put in that specific entity so we can move ourselves further ahead.

Thank you.

[The prepared statement of Mr. Hughes follows:]

Testimony of

Ian F. Hughes

Vice President, Research and Quality
Inland Steel Industries, Inc.

on behalf of

American Iron and Steel Institute

before the

SCIENCE, RESEARCH AND TECHNOLOGY SUBCOMMITTEE

of the

COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

March 8, 1989

Good morning.

I am Ian F. Hughes, Vice President, Technology, of Inland Steel Industries, Inc., speaking on behalf of the American Iron and Steel Institute, whose member companies account for approximately 80 per cent of the raw steel produced in the United States.

The integrated steel plant for the 21st century will be one of great simplicity in taking iron ore and transforming it into a product capable of meeting customer needs. The processes will be energy efficient and environmentally benign, such that a steel plant will be welcome in any community that would have the necessary access to a large tonnage of raw materials. This future steel plant will probably comprise three basic processes: the conversion of ore to liquid steel, the casting of liquid steel into thin strip, and the intelligent processing of this thin strip into the final product. It is imperative that, in order to meet this vision, long-range research be started now.

The first process step, namely, the conversion of ore to liquid steel, is being tackled under the AISI Direct Steelmaking Project, which has been accepted by the U.S. Department of Energy for negotiation of a cooperative agreement under the Steel Initiative Program. Because of the complexity of this project, it has required a multifaceted approach with input from industry, academia, and the government.

The second process step, namely, the casting of this directly made steel into thin strip, to date is lacking the R&D focus required to produce a commercialized process within the next 10 years. Thus, a collaborative industry R&D project is required in this area. This need was highlighted at a recent Forum sponsored by AISI at Northwestern

University which was designed to elicit the breakthrough areas for research that would give significant competitive advantage to the steel industry. The fact that thin strip casting has made no commercial progress in carbon steel products since Bessemer's first patentable disclosure of the subject in 1857 speaks to the extreme difficulty of both the process and product parameters that need to be solved.

The third processing step, namely that of taking the thin strip and producing a product acceptable to customers from it, is very important and is yet to be developed. Although modernization and productivity improvements have been impressive, lack of continuity and lack of process control have placed an upper limit on what can be achieved with existing technology. Thus, a third project is required, namely, the intelligent processing of thin strip into acceptable products. This initiative, which was also delineated by the AISI-Northwestern University brainstorming Forum, should focus on the measurements required for the processes to produce the products and for these measurements to be then fed back into process models and, through those process models, by appropriate control theory into a process that has excellent statistical control. The use of expert systems will be an underpinning of this intelligent processing, since many of the interactive affects between measurements and the process cannot be accurately described in the quantitative manner that process models require. The development of on-line sensors which can measure product properties and coating characteristics on strip moving at high line speeds is fundamental to this endeavor. Sensor developments will also be required to support our work on continuous steelmaking and strip casting.

The multidisciplinary challenges, involving sensor development, process modeling and process control, demand that this initiative have a

focus. An obvious best choice is the National Institute of Standards and Technology (NIST). This institute, formerly called the National Bureau of Standards, is internationally acclaimed for it's excellent intellectual and practical work in the area of measurement and standards.

Commencing with a "Workshop on Process Control Sensors for the Steel Industry," sponsored by the American Iron and Steel Institute, the Defense Advanced Research Projects Agency (DARPA), and the National Bureau of Standards (NBS) on July 27-28, 1982, there has been a continuing and highly productive collaboration between the scientists at Gaithersburg and those in the steel industry.

The recent charter for NIST has given it a new role in transferring its internal technology to industry, so there could be no other institution better suited historically--and now by mandate--to provide the focus for this project on intelligent processing project. I, therefore, strongly urge that, in accordance with S. 2470, "Steel and Aluminum Energy and Technology Competitiveness Act of 1988," funding specifically for this project should be allocated to NIST.

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**Biographical Summary**

Inland Steel

Ian F. Hughes was named Vice President, Technology, of Inland Steel Co. in December 1987, and now holds this office at Inland Steel Flat Products Co. The unit is one of two operating divisions of Inland Steel Co. He had previously been Vice President, Research and Quality, and General Manager, Research. Prior to that, he held positions of increasing management responsibility at the company's Research Laboratories.

(Inland Steel Co. is an operating subsidiary of Inland Steel Industries, Inc. Its Flat Products division — comprised of sales, manufacturing, materials and services, technology, human resources, accounting, and other support groups — produces flat-rolled sheet, strip, and plate and coated steels in East Chicago, Ind. The Technology group encompasses Research, Quality, Engineering & Environmental Affairs, Computer Systems, and New Ventures.)

Born in Great Britain, Hughes joined Inland as a research engineer in 1967 after earning a doctorate in metallurgy at London University. He progressed through a series of assignments at the Research department until being named General Manager in 1984. He assumed additional responsibility for the company's quality assurance programs in 1986 upon being appointed Vice President, Research and Quality.

Hughes is a panel member of the Institute of Materials Science & Engineering, National Bureau of Standards & Technology, and a project monitor for the American Iron and Steel Institute. He is the company representative to the Industrial Research Institute, and a member and fellow recipient of the American Society of Metals. Author of numerous published technical papers, he also holds British and American patents related to steel manufacturing technology.

Hughes resides in Munster, Ind., with his wife, Doreen; they are the parents of two children.

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Mr. WALGREN. Thank you very much, Mr. Hughes.
Mr. Fluke.

**STATEMENT OF JOHN M. FLUKE, JR., CHAIRMAN, JOHN FLUKE MANUFACTURING CO., INC. ON BEHALF OF THE AMERICAN ELECTRONICS ASSOCIATION**

Mr. FLUKE. Good morning, Mr. Chairman, members of the Committee. Thank you for your invitation to testify on behalf of the National Institute of Standards and Technology.

I appear before you today representing the American Electronics Association. In addition to serving on the AEA's board of directors, I am also the chairman of my company, John Fluke Manufacturing Co.

I hope you've had a chance to take a look at the written testimony I already submitted and will find time to read through it.

What I'd like to try to do in, hopefully, a shorter number of moments than it might take to read it, is to provide some additional perspective about NIST and the electronics industry in general.

I might start by going back to a slightly more detailed description of my company to give you some background on where my experiences have been.

The company is engaged as a manufacturer of test and measurement instrumentation, which is a very basic kind of capital equipment used by the entire rest of the electronics industry both here and abroad.

Currently, we ship abroad about 40 percent of what we manufacture. Our fastest growing markets are in Asia, specifically in places like Japan, Korea, Taiwan, Hong Kong, Singapore, and others.

We are the single remaining manufacturer of what I generally refer to as hand-held digital multivators in the United States. It's a very basic service tool that if you're bored some day and are watching a service person that comes in to fix your coffee machine in your office and look in his took kit, you might very well find a Fluke hand-held heater. We have about 30 percent of that market worldwide and, although it's a small market, it's a very good demonstration of what happens when any company, ours or any other company, vigorously attacks, enthusiastically attacks the availability of a market overseas and promptly prepares its products for that market.

The company is not necessarily a particularly large company. We have about 2,500 employees worldwide. We do business in about 80 countries typically every year. We are growing at about the same rate as the rest of our segment of the industry, which is about 10 to 15 percent a year.

I'd like now to return to the subject of NIST. When I think of NIST, I think first of the National Bureau of Standards, the historical organization behind the new NIST and I think about the things that we are now asking the National Bureau of Standards to accomplish under its new name.

And that basically includes an attack on this general area of American competitiveness. I have a concern about this process, not so much because this new additional mission for NIST is not an appropriate one—in fact, I think it is a very appropriate one. The

challenge, however, is to make sure that before funding this to any appreciable degree that we back up and examine the extent to which we are adequately funding the NBS traditional role.

In its simplest terms, this is our national body for helping industry and commerce have a basic system of weights and measures upon which we all agree. That sounds very simple. When you buy that gallon of gasoline at the gas station or that pound of butter at the grocery store, you'd like to know that you're getting exactly a gallon or a pound respectively and so would the merchant selling you those products like to know that he's not giving you too much or too little.

But, things have become a good deal more complicated than that. The range of weights and measures, if you will, that the NIST has to deal with are extremely diverse and are, indeed, at the fundamental edge of science in general.

Yet, at the other side of NIST is industry. Industry expecting and needing, demanding in the sense that it cannot live without these kinds of standards both readily available and at the leading edge with respect to where our competitors in other countries are.

Unfortunately, we find today, using the electronics industry as an example and specifically the microwave arena, we necessarily have to go to other countries to obtain acceptable levels of uncertainty in our primary standards.

This is throughout the entire telecommunications industry and the electronic instrument industry that supports it.

This is at the very least an issue of national security. You can imagine that if we are at war with one of these nations on our planet and they happen to be the best there is, or maybe the only place where we can get adequate levels of uncertainty in a certain instrumentation area, I don't think they're going to be likely to return our standards to us properly calibrated if we're at war with one another.

Thus, it is indeed a considerable national security exposure if you consider who is best at what in this area. We find countries such as Canada and England, whom we regard as friends, Japan and perhaps now China as a friend and, indeed, the Soviet Union are all sources of lower levels of uncertainty in primary standards than that which we can obtain from our own National Bureau of Standards.

The situation arises out of not just a few years but years and years of inadequate funding of the basic metrology function of the NBS, now NIST. This is something I think we need to correct in terms of appropriations.

Before we launch the NIST and do all of its new initiatives, in fact, in some ways, the new initiatives would be best served by correcting the basic metrology shortfall that exists in NIST today.

You've heard testimony here today, and I'm sure you've heard it before, on the subject of what it takes to be competitive in international markets, that it takes quite a diversity of elements. But, certainly one of them is high-product quality and low cost in manufacturing.

Today, we see American industry going through a revolution that perhaps it should have started long ago. But, basically, that revolution involves the abandoning of the so-called batch method of

manufacturing in favor of a continuous flow approach to manufacturing.

The basic underlying tenet in the old style of manufacturing, that is to say, batch manufacturing, when you examine exactly how it's done, is clearly the notion that we didn't have time to do it right the first time, but we had time to do it over.

Thus, the product was tested after it was manufactured to see if it was good or bad. The bad product was set aside to be reworked if it was. The good product of course was sent on without any corrective action necessary.

The result of this is questionable product quality because of the go it alone testing, so to speak, and how tightly it is centered on the desirable levels of operation of a given product.

We'll determine how many of those products that looked good in the factory get out into the field and drift off tolerance and fail to perform.

The difficulty that this of course poses to us is that we are a lot less efficient at manufacturing than many of our foreign competitors. What is going on in the National Bureau of Standards today might be best described as the emergency of a new field called process metrology where, instead of testing the product after the fact of manufacture, measurements are made on the process itself and used thus to control the process and keep it on its center line so that it cannot produce a bad product.

I would urge you, therefore, to carefully reconsider the recommendations that you can make with respect to appropriations, to see to it that the National Bureau of Standards function within NIST is fully funded before we proceed to the other aspects of this new initiative.

Thank you.

[The prepared statement of Mr. Fluke follows:]

TESTIMONY OF
MR. JOHN M. FLUKE, JR.
CHAIRMAN
JOHN FLUKE MANUFACTURING COMPANY, INC.
ON BEHALF OF THE
AMERICAN ELECTRONICS ASSOCIATION
BEFORE THE
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVES
MARCH 8, 1989

MR. CHAIRMAN AND MEMBERS OF THE COMMITTEE, THANK YOU FOR YOUR INVITATION TO TESTIFY ON THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY. I APPEAR BEFORE YOU TODAY REPRESENTING THE AMERICAN ELECTRONICS ASSOCIATION (AEA). IN ADDITION TO SERVING ON AEA'S BOARD OF DIRECTORS, I AM THE CHAIRMAN OF THE BOARD OF JOHN FLUKE MANUFACTURING, CO.

THROUGH MY 23 YEAR ASSOCIATION WITH JOHN FLUKE MANUFACTURING CO., WHICH WAS FOUNDED BY MY FATHER OVER 40 YEARS AGO, I HAVE GAINED FIRST HAND KNOWLEDGE OF THE IMPORTANCE OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, PARTICULARLY ITS MEASUREMENT AND STANDARDS ACTIVITIES, TO AMERICAN BUSINESS. FOR THOSE UNFAMILIAR WITH MY COMPANY, FLUKE IS HEADQUARTERED AND HAS MANUFACTURING FACILITIES IN EVERETT, WASHINGTON AND HAS SALES OFFICES WORLD WIDE. WE ARE A LEADING MANUFACTURER OF TEST AND MEASURING INSTRUMENTATION, WITH SOME 2400 EMPLOYEES AND ANNUAL SALES REVENUES OF OVER $220 MILLION.

THROUGH MY AFFILIATION WITH AEA, I HAVE ENHANCED MY KNOWLEDGE OF U.S. ELECTRONICS COMPANIES' SHARED CONCERNS AND EVOLVING REQUIREMENTS FOR THE INDUSTRY'S LONG-TERM INTERNATIONAL

COMPETITIVENESS. AS YOU MAY KNOW, AEA IS A NATIONAL ORGANIZATION REPRESENTING SOME 3,500 COMPANIES THAT DESIGN, MANUFACTURE OR CONDUCT RESEARCH IN ELECTRONICS, ELECTRONIC COMPONENTS, AND RELATED INFORMATION TECHNOLOGY PRODUCTS. IN ADDITION, AEA HAS RECRUITED A GROWING NUMBER OF UNIVERSITIES AS ASSOCIATE MEMBERS TO FOSTER CLOSER WORKING RELATIONSHIPS BETWEEN INDUSTRY AND ACADEMIA.

NIST FUNDING FOR COMPETITIVENESS

IT IS IN BOTH MY AEA AND FLUKE CAPACITIES THAT I PRESENT TESTIMONY ON THE CRITICAL ROLE NIST PLAYS IN INCREASING U.S. COMPETITIVENESS. COMPETITIVENESS REQUIRES NOT ONLY DEVELOPMENT OF LEADING-EDGE TECHNOLOGIES, BUT THEIR SUCCESSFUL COMMERCIALIZATION. CONGRESS RESPONDED TO THIS NEED LAST YEAR BY SIGNIFICANTLY ADDING TO THE INSTITUTE'S CORE METROLOGY MISSION THE RESPONSIBILITY FOR IMPROVING QUALITY, MODERNIZING MANUFACTURING PROCESSES, AND FACILITATING THE TRANSFER AND COMMERCIALIZATION OF NEW TECHNOLOGY. THIS ACTION IS STRONGLY SUPPORTED BY AEA AND FLUKE.

UNFORTUNATELY, THE ADMINISTRATION HAS NOT YET PROPOSED TO AUGMENT THE INSTITUTE'S BUDGET TO FUND THE NEW RESPONSIBILITIES. THE PROPOSED FUNDING FOR NIST BARELY KEEPS PACE WITH INFLATION, AND NO FISCAL YEAR 1990 FUNDS HAVE BEEN PROVIDED FOR NIST'S NEW

TECHNOLOGY TRANSFER FUNCTIONS. BOTH THE INSTITUTE'S TRADITIONAL MEASUREMENT AND QUALITY ASSURANCE ROLE, AND ITS NEW MANUFACTURING AND TECHNOLOGY TRANSFER FUNCTIONS MUST BE ADEQUATELY FUNDED IF THE NEW NIST IS TO HAVE THE DESIRED EFFECT OF HELPING INDUSTRY COMPETE IN THE GLOBAL MARKETPLACE.

METROLOGY -- QUALITY -- COMPETITIVENESS

THE LOWEST PRICED PRODUCT IS NOT NECESSARILY THE MOST COMPETITIVE PRODUCT. CUSTOMERS WANT QUALITY PRODUCTS, DELIVERED ON TIME, WHICH MEET THEIR SPECIAL NEEDS, AND THEY ARE WILLING TO PAY FOR THEM. WE NEED ONLY TO LOOK AROUND US AT ALL THE JAPANESE AUTOMOBILES AND CONSUMER ELECTRONICS FOR EVIDENCE OF THIS.

THERE IS AN IRREVOCABLE LINK BETWEEN PRODUCT QUALITY AND MEASUREMENT WHICH HAS BEEN LARGELY OVERLOOKED IN THIS COUNTRY. THE KEY TO THE TESTING REQUIRED BY A MODERN, EFFICIENT AND EFFECTIVE QUALITY CONTROL PROGRAM IS SOUND AND PROPER MEASUREMENT, BASED ON A PROGRAM OF STANDARDIZATION TO ASSURE THE ACCURACY OF MEASUREMENTS. MEASUREMENT STANDARDIZATION IS ACHIEVED MOST EFFICIENTLY THROUGH AN EFFECTIVE, WELL UNDERSTOOD AND PROPERLY FUNCTIONING NATIONAL MEASUREMENT SYSTEM, HEADED BY A COMPETENT AND COMMITTED NATIONAL STANDARDS LABORATORY.

COMPETENCE AND COMMITMENT ARE NEEDED NOT ONLY FOR ESTABLISHING

AND MAINTAINING THE BASIC STANDARDS UPON WHICH MEASUREMENT ACCURACY DEPENDS, BUT ALSO FOR DEVELOPING THE DEVICES AND APPARATUS FOR SCALING TO MULTIPLES AND FRACTIONS OF THOSE STANDARDS. ALSO NEEDED IS EFFECTIVE AND EFFICIENT APPARATUS TO MAKE THE BENEFITS OF STANDARDIZATION AVAILABLE TO INDUSTRY. COMPETENCE OF THE LEVEL REQUIRED WILL NOT BE ACHIEVED OR EVEN MAINTAINED WITH NO-GROWTH BUDGETS AND DECLINING PERSONNEL LEVELS WITHIN NIST.

ARE WE LOSING THE INTERNATIONAL MEASUREMENTS RACE?

AT THE END OF WORLD WAR II, NIST, FORMERLY THE NATIONAL BUREAU OF STANDARDS, WAS THE UNDISPUTED LEADER OF THE WORLD METROLOGY COMMUNITY. AT SOME POINT IN THE 1960'S, HOWEVER, NIST APPEARS TO HAVE LOST THE SENSE OF MISSION WHICH HAD ENABLED IT TO ACHIEVE THAT POSITION OF LEADERSHIP. BUDGET PROBLEMS, AND TO SOME EXTENT, MANAGEMENT DECISIONS, BEGAN TO ERODE THE BASE OF MONETARY AND OTHER RESOURCES WHICH HAD BEEN DEDICATED TO ADVANCEMENT OF ITS PRIMARY MISSION, THE ESTABLISHMENT AND MAINTENANCE OF AN ADEQUATE AND ACCESSIBLE SYSTEM OF MEASUREMENT STANDARDS. SEVERAL COUNTRIES, INCLUDING GERMANY, ENGLAND, FRANCE, RUSSIA, JAPAN, AUSTRALIA, AND CANADA NOW MATCH NIST CAPABILITIES IN THE BASIC MEASUREMENT AREAS. FOR THE MOST PART, THEY ARE USING TECHNOLOGIES DEVELOPED BY NIST IN ITS "GOLDEN" PERIOD.

OF MUCH MORE CONCERN IS THE FACT THAT THESE SAME COUNTRIES, PLUS CHINA, NOW FAR SURPASS NIST CAPABILITIES IN A NUMBER OF MEASUREMENT AREAS. AT THE SAME TIME, AND ALSO OF MUCH CONCERN, IS THE FACT THAT THE U.S. HAS NO STANDARDS AND MEASUREMENT CAPABILITY IN SEVERAL MEASUREMENT AREAS IMPORTANT TO U.S. INDUSTRY. NOT ONLY IS THE U.S. IN DANGER OF BECOMING A SECOND CLASS CITIZEN IN WORLD MEASUREMENTS AND STANDARDS, BUT WE ALSO HAVE LOST OUR STRONG CAPABILITY IN MODELLING AND COMMUNICATING THE MEASUREMENT PROCESS. INDUSTRY IS CURRENTLY STRUGGLING WITH ATTEMPTS TO IMPLEMENT TECHNIQUES FOR COMPUTING AND REPORTING MEASUREMENT UNCERTAINTIES WHICH WERE PUBLISHED BY NIST 20 TO 25 YEARS AGO - A STRUGGLE WHICH SHOULD HAVE BEEN MADE UNNECESSARY BY PROPER GUIDANCE BY NIST PROFESSIONALS IN THESE DISCIPLINES. AND NOW NIST'S EFFECTIVENESS IS BEING FURTHER REDUCED BY THE RETIREMENT OF A SUBSTANTIAL NUMBER OF METROLOGY SENIOR SCIENTISTS.

LONG-TERM COMMITTMENT TO NIST

FUNDAMENTAL CHANGES IN FUNDING DIRECTION ARE NECESSARY TO RESTORE U.S. COMPETITIVENESS IN METROLOGY AND ENSURE THE RAPID AND EFFECTIVE TRANSFER OF TECHNOLOGY TO U.S. INDUSTRY. HOLDING THE LINE ON BUDGETS WILL NOT BE ENOUGH TO RESTORE NIST CAPABILITIES TO THE LEVEL NEEDED. A SUBSTANTIAL INCREASE IN NIST'S METROLOGY BUDGET IS NEEDED TO REVERSE YEARS OF NEGLECT OF

NIST'S PRIMARY MISSION - RESEARCH, DEVELOPMENT, AND DISSEMINATION OF ADEQUATELY PRECISE AND ACCURATE MEASUREMENT, MEASUREMENT STANDARDS, AND METHODS OF MEASUREMENT. THIS INCREASE IS OVER AND ABOVE THAT WHICH IS NEEDED TO SUPPORT THE NIST'S NEW RESPONSIBILITIES.

THE SUCCESS OF NIST WILL DIRECTLY AFFECT U.S. INDUSTRY'S ABILITY TO COMPETE IN WORLD MARKETS. ADEQUATE FUNDING MUST BE PROVIDED TO ACCOMPLISH THESE ENDS WITHIN A REASONABLE PERIOD - SAY FIVE YEARS - AND CLOSE OVERSIGHT MUST BE PROVIDED TO ASSURE PROPER PLANNING AND EXECUTION OF PROGRAMS TO ACHIEVE THESE GOALS.

THE COMMITTEE'S LEADERSHIP IS URGENTLY NEEDED TO PROVIDE A LONG-TERM PLAN, WITH APPROPRIATE INCREASES IN AUTHORIZATION AND APPROPRIATION, TO REDRESS NIST'S INABILITY TO KEEP PACE WITH BOTH THE GROWING NEED FOR PRECISION MEASUREMENTS AND THE TRANSFER OF TECHNOLOGY. AEA APPLAUDS THE COMMITTEE'S SUCCESS IN ENACTING A FIVE-YEAR AUTHORIZATION FOR THE NATIONAL SCIENCE FOUNDATION AND SUPPORTING A DOUBLING OF THAT AGENCY'S BUDGET. I URGE THE COMMITTEE TO RECOMMEND A COMPARABLE INVESTMENT IN NIST. IF WE ARE SERIOUS ABOUT THE NEED TO TURN BASIC RESEARCH INTO QUALITY PRODUCTS, NIST MUST BE ADEQUATELY FUNDED.

AS A COMPLEMENT TO CONGRESSIONAL LEADERSHIP, NIST ALSO IS IN DIRE NEED OF STRONG INTERNAL LEADERSHIP. I ASK THE COMMITTEE TO JOIN

WITH AEA IN URGING THE ADMINISTRATION TO EXPEDITIOUSLY NOMINATE FOR THE POSITIONS OF UNDERSECRETARY FOR TECHNOLOGY AND DIRECTOR OF NIST KNOWLEDGEABLE, EXPERIENCED INDIVIDUALS WHO WILL PROVIDE THE NECESSARY LEADERSHIP FOR THE TECHNOLOGY ADMINISTRATION AND NIST -- INDIVIDUALS WHO UNDERSTAND INDUSTRY'S NEEDS AND ARE WILLING TO AGGRESSIVELY PURSUE THEIR NEW AGENCY'S MISSION.

NEW INITIATIVES

AEA STRONGLY DISAGREES WITH THE ADMINISTRATION'S INITIAL DECISION TO PROVIDE NO FUNDS IN FISCAL YEAR 1990 FOR NIST'S NEW TECHNOLOGY TRANSFER PROGRAMS: THE REGIONAL CENTERS FOR THE TRANSFER OF MANUFACTURING TECHNOLOGY; THE INDUSTRIAL EXTENSION SERVICES PROGRAM; THE ADVANCED TECHNOLOGY PROGRAM; AND THE CLEARINGHOUSE FOR STATE TECHNOLOGY PROGRAMS. THERE IS NO QUESTION THAT THE FEDERAL GOVERNMENT HAS AN IMPORTANT ROLE TO PLAY IN HELPING INDUSTRY TO IMPROVE THE APPLICATIONS OF CIVILIAN TECHNOLOGY, AND THUS REMAIN COMPETITIVE IN WORLD MARKETS. NIST'S NEW INITIATIVES ARE AN INNOVATIVE AND APPROPRIATE APPROACH TO IMPROVING TECHNOLOGY TRANSFER.

BECAUSE OF THE ELECTRONICS INDUSTRY'S LARGE MANUFACTURING SEGMENT AND ITS ENTREPRENEURIAL NATURE, NIST'S TECHNOLOGY TRANSFER INITIATIVES ARE PARTICULARLY IMPORTANT. ELECTRONICS IS AMERICA'S LARGEST MANUFACTURING INDUSTRY. OVER 2.6 MILLION

AMERICAN WORKERS ARE DIRECTLY EMPLOYED IN ELECTRONICS MANUFACTURING. THIS IS THREE TIMES THE SIZE OF THE AUTO INDUSTRY, AND NINE TIMES THE SIZE OF THE STEEL INDUSTRY. IN ADDITION, THE ELECTRONICS INDUSTRY IS ENTREPRENEURIAL IN NATURE. OVER HALF OF AEA'S 3,500 MEMBER COMPANIES ARE LESS THAN 10 YEARS OLD. NEARLY THREE-QUARTERS OF AEA'S MEMBER COMPANIES ARE SMALL BUSINESSES EMPLOYING FEWER THAN 200 PEOPLE. PROGRAMS SUCH AS NIST'S REGIONAL CENTERS FOR THE TRANSFER OF MANUFACTURING TECHNOLOGY, WHICH ARE AIMED AT BRINGING MODERN MANUFACTURING TECHNOLOGY TO SMALL AND MID-SIZE FIRMS, COULD BE OF GREAT BENEFIT TO LARGE SEGMENTS OF THE ELECTRONICS INDUSTY.

ALONG WITH MY SUPPORT FOR THESE ACTIVITIES, I ALSO OFFER A SUGGESTION. IT HAS BEEN PROPOSED THAT EACH OF THE TWELVE REGIONAL TECHNOLOGY TRANSFER CENTERS BE EQUIPPED WITH A FLEXIBLE MANUFACTURING SYSTEM, WITH AN EMPHASIS ON THE MACHINE TOOL ASPECT OF MANUFACTURING. I RECOMMEND THAT NIST BE DIRECTED TO ESTABLISH CENTERS WHICH WILL SPECIALIZE IN ONE OF SEVERAL OTHER MANUFACTURING TECHNOLOGIES. SUCH CENTERS SHOULD INCLUDE STATE OF THE ART AUTOMATED ELECTRONICS MANUFACTURING AND METROLOGY CENTERS WHOSE MISSION WOULD BE TO COMMUNICATE THE PROPER APPLICATION OF METROLOGY TO THE CONTROL OF QUALITY. THESE SPECIALIZED CENTERS SHOULD BE LOCATED TO MAXIMIZE THE IMPACT UPON INDUSTRY IN THE REGIONS SURROUNDING THE CENTER.

NIST AND INDUSTRY-LED CONSORTIA

IN ADDITION TO CARRYING OUT THE BASIC TECHNOLOGY TRANSFER ACTIVITIES ENVISIONED BY CONGRESS IN ITS CREATION OF NIST, I WOULD ALSO SUGGEST THAT THE ADVANCED TECHNOLOGY PROGRAM CAN PLAY A NEW ROLE IN FACILITATING TECHNOLOGY DEVELOPMENT. THERE APPEARS TO BE A GENERAL CONSENSUS THAT MORE COORDINATED INDUSTRY/GOVERNMENT EFFORTS ARE NEEDED IN ORDER FOR THE U.S. TO BE INTERNATIONALLY COMPETITIVE IN CERTAIN TECHNOLOGIES. WITH ADEQUATE SUPPORT, NIST'S ADVANCED TECHNOLOGY PROGRAM COULD BE A VALUABLE TOOL FOR COORDINATING AND FINANCING THE FEDERAL GOVERNMENT'S PARTICIPATION IN INDUSTRY-LED CONSORTIA FOCUSED ON CRITICAL TECHNOLOGIES. ADVANCED TELEVISION, OR HIGH DEFINITION TELEVISION (HDTV) HAS BEEN IDENTIFIED AS ONE OF THE CRITICAL EMERGING TECHNOLOGIES THAT WILL HAVE A SIGNIFICANT IMPACT ON THE LONG-TERM ECONOMIC HEALTH AND COMPETITIVENESS OF THE U.S. NIST, UNDER THE LEADERSHIP OF THE NEW UNDERSECRETARY FOR TECHNOLOGY, COULD PLAY THE LEADING FEDERAL ROLE IN ASSISTING INDUSTRY WITH THE DEVELOPMENT AND COMMERCIALIZATION OF CIVILIAN ADVANCED TELEVISION TECHNOLOGIES.

CONCLUSION

IN NIST CONGRESS HAS PROVIDED INDUSTRY WITH A PROMISING STRUCTURE TO PROMOTE THE DEVELOPMENT OF LEADING-EDGE TECHNOLOGIES AND

THEIR SUCCESSFUL COMMERCIALIZATION. NOW CONGRESS NEEDS TO FULFILL THIS PROMISE BY PROVIDING A SIGNIFICANT, LONG-TERM EXPANSION OF NIST'S BUDGET TO RESTORE U.S. COMPETITIVENESS IN METROLOGY AND ENSURE THE RAPID TRANSFER OF TECHNOLOGY TO INDUSTRY. THE HEALTH OF THIS COUNTRY'S ECONOMY AND ITS ABILITY TO COMPETE IN INCREASINGLY HIGH-TECH WORLD MARKETS IS CRITICALLY DEPENDENT UPON THE VIGOR WITH WHICH NIST IS ABLE TO PURSUE ITS MISSION.

THANK YOU, AGAIN, FOR THIS OPPORTUNITY TO TESTIFY. I WILL BE HAPPY TO ANSWER ANY QUESTIONS.

Mr. WALGREN. Thank you, Mr. Fluke.
Mr. Berge.

**STATEMENT OF JAMES H. BERGE, VICE PRESIDENT, FIBER OPTICS DIVISION, TELECOMMUNICATIONS INDUSTRY ASSOCIATION**

Mr. BERGE. Thank you, Mr. Chairman, members of the Subcommittee. I'm James H. Berge, vice president of the Telecommunications Industry Association. My primary responsibility is the administration of the TIA's Fiber Optics Division.

I appreciate the opportunity to appear before this Subcommittee today to discuss the role of NIST in the growth and competitiveness of the U.S. Fiber Optics Imdustry.

The Telecommunications Industry Association is a full service national trade association representing nearly 600 manufacturers and suppliers of telecommunications equipment.

It functions as a telecommunications arm of the Electronics Industry Association. Our companies are engaged in the design and manufacture of fiber optic components and systems here in the United States.

Of those 600 companies 46 are engaged in the manufacture of fiber optics. Those 46 corporations are listed in the appendix. The United States today is the largest telecommunications market in the world and, consequently, the largest single fiber optics market.

The U.S. share of the world fiber optics market is currently about 40 percent, but that share is forecast to decrease as the installation of fiber in Western Europe and Asia out-paces the United States over the next 5 years.

This year, the U.S. market is expected to reach 1.1 billion of a total world market of 3.2 billion. Over 450 U.S. companies are now involved in fiber optic production. Most of them are quite small and many are having a difficult time.

The shrinking U.S. share is likely to further intensify competition in the domestic market and lead some U.S. firms to pursue the expanding foreign markets.

The problem is that the long-haul installation of fiber by the major inter-exchange carriers is largely complete and growth in this market has leveled.

For instance, the cumulative route miles for long-haul carriers has gone from 20,000 in 1985 to over 80,000 in 1988. At the regional level, the seven Bell operating companies have gone from 18,000 miles in 1985 to 62,000 in 1988.

The RBOCs will continue to install fiber along central trunk routes to major customers in the next several years, but the growth is not predicted to exceed that of recent years.

The next frontier and most promising market for fiber optics is the local loop. The subscribers assigned to the central office, it is estimated that there is 10 times more potential business in this area of the telephone plant than in the inter-office and long haul plant.

Local loops account for 90 percent of the telephone system links in the country. And electronic cast projections state that residen-

tial sales alone could take a 75-percent share of a $4 billion U.S. fiber optics market by 1995.

They also predict that up to 1.5 million homes could be hooked up with fiber optic by 1997. The more conservative estimate has placed the 4 billion figure in about 1999.

We in the industry don't want to wait 8 to 10 years for fiber optics communications to become available to the consumer. We believe the technology is sufficiently developed and the manufacturing base sufficiently established to move this time period three to five years closer.

HDTV is just over the horizon and its success would be greatly enhanced with a signal transmitted over fiber.

Incidentally, we submitted a report to Congressman Markey asking that he include fiber optics technology initiatives to enhance national competitiveness related to the HDTV. A copy of that submission is included as appendix B.

Fiber optic local area networks are coming which provide the bandwidth for office computer systems using the full capability of an integrated system digital network. Our homes and schools can become fully automated with multiple video projections that will entertain, inform and educate. But we need your help.

Our Fiber Optics Division has been working closely with NIST for the past 10 years in the development of test procedures and specifications. We have now published 92 fiber optic test procedures.

NIST has provided the measurement basis for 25 of them. This has been a technology transfer function from its inception. They have defined the standard for absolute measurement of optical power for the development of light sources and detectors.

NIST has completed its first system for high-speed measurement of optical wave forms to support the development of fast optical devices, such as optical modulators. They conduct their work at their facility in Boulder, CO and they oversee the round robin testing that we do at the various laboratories of our component and systems manufacturers.

Their expertise in light wave measurement, their extensive laboratory test facilities and their unique professional and objective approach to test and research projects have made their partnership and participation invaluable.

That support is now needed more than ever.

One of the reasons that our industry growth is now relatively stagnant is that the cost of the optical systems that would bring fiber to the home is too high. The price gap between fiber optics and copper cable is closing, but the cost of the total systems, including key components such as sources and detectors, remains too high.

There is a driving need to improve reliability and performance and to lower costs, all highly measurement-dependent aims.

Our success in meeting this need will play a large part in deciding how soon we are ready for fiber to the home and how much market will be left for U.S. manufacturers here and throughout the world when we are ready.

Specifically, we ask that NIST receive the $2.6 million requested in the President's budget for fiscal year 1990. They intend to apply

these funds to the high-priority component characteristic, which will increase performance and reliability and decrease cost.

In the light source area, lasers and LEDs, they will measure linewidth and wave-length to closer tolerances in preparation for research on multiplexing and coherent communications, which will increase band-width and clarity and reduce costs.

For detectors, the funding will enable expansion to include measurements for electronic noise, characterization of detector amplifier packages and the fabrication of special detectors to correlate design with noise performance and sensitivity.

Improved noise performance will reduce errors in transmission and allow a reduction in the number of repeaters along a fiber optic communication line.

That reduction reduces the cost and increases the reliability of the line.

Fibers or wave-guides themselves can be improved to better pass the light waves through their length. By improving measurement techniques, NIST will be able to point out wave-guide defects which will enable the manufacture of improved fiber products.

NIST also plans to improve modulators and connectors all critical to the quality, performance and reliability of a fiber-optic communications system.

They will be expanding their existing program for characterizing lithium niobate modulators to additional types of pulse code modulators. This work is preparatory to new technology in multiplexing and coherent communications.

They will be expanding their loss measurement work on passive couplers to include measurements for band-width and coupling geometry. Couplers must meet rigid requirements for band-width preservation to prevent degradation of system performance.

The projects and improvements included in the $2.6 million are the minimum required to keep our fiber-optics industry moving ahead in technology.

I'm not sanguine about keeping up with our overseas competitors, who are rapidly expanding as they install their own fiber long lines and local area networks while we wait for political decisions and technological improvements which will make it possible to expand fiber to business and the home.

When it comes to performance, reliability and cost, there are additional steps that should be taken to keep us competitive. Additional breakthroughs in distributing optical signals through switches to multiple uses and locations, expanding band-widths through better wave guides and transmitting techniques, and improving overall system performance are a few that are in NIST's bailiwick.

Additional funding beyond the $2.6 million this year or next for projects of this nature would help immensely to keep this industry motivated and aggressive.

Fiber optics is the communications medium of the future. The largest market is here in the United States and we have the manufacturers to produce the product. The technology is still developing like any new industry. But, the basic capability is here and now, not in the next century.

I would urge that this Subcommittee do all it can to provide the funding and emphasis so necessary to keep this native U.S. industry in the forefront of this amazing communications revolution.

Thank you for listening. I'd be happy to answer questions.

[The prepared complete statement of Mr. Berge follows:]

TESTIMONY OF

JAMES H. BERGE

VICE PRESIDENT

FIBER OPTICS DIVISION

OF THE

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

ON

NIST AND THE U.S. FIBER OPTICS INDUSTRY

MARCH 8, 1989

Good morning, Mr. Chairman and Members of the Subcommittee. I am James H. Berge, Vice President of the Telecommunications Industry Association with primary responsibility for the administration of TIA's Fiber Optics Division. I appreciate the opportunity to appear before this subcommittee today to discuss the role of the National Institute of Standards and Technology in the growth and competitiveness of the U.S. Fiber Optics Industry.

The Telecommunications Industry Association is a full service national trade association representing nearly 600 manufacturers and suppliers of telecommunications equipment. Forty-six of those companies are engaged in the design and manufacture of fiber optic components and systems here in the United States. The 46 corporations are listed in Appendix A to this testimony.

The U.S. is, today, the largest telecommunications market in the world and consequently, the largest single fiber optics market. The U.S. share of the world fiber optics market is currently about 40%, but that share is forecast to decrease as the installation of fiber in Western Europe and Asia outpaces the U.S. over the next five years. This year the U.S. market is expected to reach $1.1 billion of a total world market of $3.2 billion. Over 800 U.S. companies are now involved in the production of fiber optics. Most

of them are quite small and many are having a very difficult time. The shrinking U.S. share is likely to further intensify competition in the domestic market and lead some U.S. firms to pursue the expanding foreign markets.

The problem is that the long haul installation of fiber by the major interexchange carriers is largely complete and growth in this market has leveled. For instance, the cumulative route miles for long-haul carriers has gone from 20,000 in 1985 to over 80,000 in 1988. At the regional level the seven Bell Operating companies have gone from 18,000 in 1985 to 62,000 in 1988. RBOCs will continue to install fiber along central trunk routes and to major customers in the next several years, but the growth is not predicted to exceed that of recent years. The next frontier and most promising market for fiber optics is the local loop, the subscriber's side of the central office. It is estimated that there is ten times more potential business in this area of the telephone plant than in the interoffice and long-haul plant. Local loops account for 90 percent of the telephone system links in the country. An Electronicast forecast notes that residential sales alone could take a 75% share of a $4 billion fiber optics market by 1995. They also predict that up to 1.5 million homes could be hooked up with fiber optics by 1997. The more conservative estimates would place the $4 billion figure in about 1999.

We in the industry don't want to wait eight to ten years for fiber optic communications to become available to the consumer. We believe that the technology is sufficiently developed and the manufacturing base sufficiently established to move this time period three to five years closer. HDTV is just over the horizon and its success would be greatly enhanced with a signal transmitted over fiber. Incidently, we submitted a report to Congressman Markey, Chairman of the Telecommunications and Finance Subcommittee on February 1st, asking that he include fiber optic technology initiatives to enhance national competitiveness related to HDTV. A copy of that report is included in my testimony as Appendix B. Fiber local area networks will provide the bandwidth for office computer systems using the full capability of an integrated system digital network (ISDN). Our homes and schools can become fully automated with multiple video projections that will entertain, inform and educate. But, we need your help.

Our Fiber Optics Division has been working closely with the National Bureau of Standards, now NIST, for the past ten years in the development of test procedures and specifications. There are now 92 fiber optic test procedures published. NIST has provided the measurement basis for 25 of them. This has been a technology transfer function from its inception. They have defined a standard for absolute measurement of optical power for the

development of light sources and detectors. NIST has completed its first system for high-speed measurement of optical wave forms to support the development of fast optical devices such as optical modulators. They conduct their work at their facility in Boulder, Colorado and they oversee the "round robin" testing that we do at the various laboratories of our component and system manufacturers. Their expertise in lightwave measurement, their extensive laboratory test facilities and their unique professional and objective approach to test and research projects have made their participation and partnership with us invaluable. That support is now needed more than ever. One of the reasons that our industry growth is now relatively stagnant is that the cost of the optical systems that would bring fiber to the home is too high. The price gap between fiber optics and copper cable is closing, but the cost of the total system including key components such as sources and detectors remains too high. There is a driving need to improve reliability, and performance, and to lower costs, all highly measurement dependent aims. Our success in meeting this need will play a large part in deciding how soon we ready fiber for the home and how much market will be left for U.S. manufacturers, here and throughout the world, when we are ready.

Specifically, we request that NIST receive the $2.6 million requested in the President's Budget for FY-90. They intend to apply these funds to the high priority component characteristi

which will increase performance and reliability and decrease cost. In the light source area, lasers and LEDs, they will measure linewidth and wave length to closer tolerances in preparation for research on multiplexing and coherent communications which will increase bandwidth and clarity and reduce costs.

For detectors, the funding will enable expansion to include measurements for electronic noise, characterization of detector amplifier packages, and the fabrication of special detectors to correlate design with noise performance and sensitivity. Improved noise performance will reduce errors in transmission and allow a reduction in the number of repeaters along a fiber communication line. That reduction reduces the cost and increases the reliability of the line.

Fibers, or waveguides, themselves can be improved to better pass the lightwaves through their length. By improving measurement techniques, NIST will be able to point out waveguide defects which will enable the manufacture of improved fiber products. NIST also plans to improve modulators and connectors, all critical to the quality, performance and reliability of a fiber optic communications system. They will be expanding their existing program for characterizing lithium niobate modulators to additional types of pulse code modulators. This work is preparatory to new technology in multiplexing and coherent communications. They will

be expanding their loss measurement work on passive couplers to include measurements for bandwidth and coupling geometry. Couplers must meet rigid requirements for bandwidth preservation to prevent degradation of system performance.

The projects and improvements included in the $2.6 million in funding described above are the minimum required to keep our Fiber Optics Industry moving ahead in technology. I'm not sanguine about keeping up with our overseas competitors who are rapidly expanding as they install their own fiber long lines and local area networks, while we wait for political decisions and technological improvements which will make it possible to expand fiber to business and the home. When it comes to performance, reliability and cost, there are additional steps that must be taken to keep us competitive. Additional breakthroughs in distributing optical signals through switches to multiple users and locations, expanding bandwidth through better wave guides and transmitting techniques, and improving overall system performance are a few that are in NIST's bailiwick. Additional funding beyond the $2.6 million this year or next for projects of this nature would help immensely to keep this industry motivated and aggressive.

Fiber Optics is the communication medium of the future. The largest market is here in the U.S. and we have the manufacturers to produce the product. The technology is still developing, like

any new industry, but the basic capability is here and now, not in the next century. I would urge that this sub-committee do all it can to provide the funding and emphasis so necessary to keep this native industry in the lead as we move forward in this communication revolution.

Thank you for the opportunity to appear before you. I would be pleased to answer your questions.

APPENDIX A

CHAIRMAN: The current Chairman of the Fiber Optics Division is Mr. Jan Suwinski of Corning Glass.

MEMBER COMPANIES: The following are the current member companies in the Fiber Optics Divison:

| | | |
|---|---|---|
| ADC Telecommunications | Bloomington | MN |
| Alcatel | Raleigh | NC |
| Alcoa Fujikura Ltd. | Pittsburgh | PA |
| American Fiber Optics Corporation | Signal Hill | CA |
| AMP Incorporated | Harrisburgh | PA |
| AT&T | Baskin Ridge | NJ |
| BT&D Technologies | Wilmington | DE |
| Buehler Ltd. | Lake Bluff | IL |
| Cooper Industries/Belden Wire & Cable | Richmond | IN |
| Corning Glass Works | Corning | NY |
| Dow Chemical USA | Granville | OH |
| DSC Communications Corp. | Plano | TX |
| EG&G Princeton Applied Research | Princeton | NJ |
| Ensign-Bickford Optics Company | Avon | CT |
| Finisar Corporation | Menlo Park | CA |
| Fitel Corporation | Carrollton | GA |
| Gould Inc. | Rolling Meadows | MD |
| Harris Corporation | Melbourne | FL |
| Henkels and McCoy, Inc. | Blue Bell | PA |
| Hughes Network Systems | Los Angeles | CA |
| International Business Machines | Bethesda | MD |
| Lytel Inc. | Summerville | NJ |
| Martin Marietta Corporation | Bethesda | MD |
| Minerich, Inc. | Richmond | KY |
| The Mitre Corporation | Bedford | MA |
| NEC America, Inc. | Melville | NY |
| Northern Telecom Inc. | Nashville | TN |
| Ortel Corporation | Alhambra | CA |
| PCO, Inc. | Chatsworth | CA |
| Photodyne, Inc. | Camerillo | GA |
| Photon Kinetics, Inc. | Beverton | OR |
| Pirelli Cable Corporation | Lexington | SC |
| Raychem Corporation | Menlo Park | CA |
| Reliance Comm/Tec | Chicago | IL |
| Rockwell International Corporation | Pittsburgh | PA |
| Siecor Corporation | Hickory | NC |
| Siemens Capital Corporation | New York | NY |
| SpecTran Corporation | Sturbridge | MA |
| SNC Manufacturing Co., Inc. | Oshkosh | WI |
| Stromberg Carlson Corp | Lake Mary | FL |
| Sumitomo Electric Fiber Optic Corporation | Research Triangle | NC |
| Telect, Inc. | Spokane | WA |
| Thomas & Betts Corporation | Bridgewater | NJ |
| 3M/Dorran | Atlantic Highlands | NJ |
| Wilcom Industries | Laconia | NH |
| York Technology | Princeton | NJ |

EIA STAFF CONTACT: Hal Berge, Vice President, TIA, 202/457-8737

APPENDIX B

TELECOMMUNICATIONS TIA INDUSTRY ASSOCIATION

February 6, 1989

The Honorable Edward J. Markey
Chairman, Subcommittee on
Telecommunications and Finance,
Committee on Energy and Commerce
U.S. House of Representatives
Washington, D.C. 20515

Dear Chairman Markey:

The Fiber Optics Division of the Telecommunications Industry Association (TIA) responded to your committee regarding the competitiveness of the United States in the emerging HDTV market. Our submission is included as Appendix C to the report of the Advanced Television Committee of the Electronics Industry Association (EIA). TIA is affiliated with EIA and represents the telecommunications sector of the electronics industry.

In our view the technologies of fiber optics communications and of HDTV are closely related because of their relevance to expanded bandwidth. This synergy when understood and applied will lead to a superior television product for both the domestic and world markets. We therefore urge that you include fiber optic technology in initiatives to enhance national competitiveness related to HDTV.

We would be pleased to answer any questions you may have on fiber optics technology. A copy of our response is included with this letter.

Sincerely,

Jan H. Suwinski

Jan Suwinski, Chairman
Fiber Optics Division

Encl.

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202/457-4912 • TWX 710-822-0148 • FAX: 202/457-4939
Representing the telecommunications industry in association with the Electronic Industries Association (EIA)

ATTACHMENT TO APPENDIX B

## APPENDIX C

### INTRODUCTION

The Fiber Optics Division of the Telecommunications Industry Association believes U.S. competitiveness can be increased by adopting a system approach that incorporates optical fiber and that this issue deserves an additional submission.

The Fiber Optics Division of TIA is made up of 42 companies manufacturing optical fiber components and systems for the telecommunications industry. We would be pleased to comment further in answer to your queries or to testify at hearings in support of our position.

### SUMMARY

The division believes that a synergistic relationship exists between HDTV and fiber optics. Optical fibers can deliver a higher quality signal than other media. Therefore, extensive use of fiber optics can aid HDTV in becoming a commercial success. In turn, the success of HDTV can make a major contribution to the continued growth and vitality of the U.S. Fiber Optics industry.

We strongly favor a competitive domestic HDTV industry and believe that the development of a U.S. system based on our national requirements and capabilities is essential. We also believe that the electronic equipment technologies of the HDTV and fiber optic industries share a common base in which the enhancement of either can significantly benefit the other. It is our position that U.S. competitiveness will be enhanced by developing the strongest possible domestic HDTV technology.

The Division considers that the United States has a rare opportunity at this time to advance its video industry because of the concurrent rapid development of HDTV, fiber optics and large scale integrated circuit technology. However, it is a difficult task to develop systems that take full advantage of three simultaneously advancing technologies. This is particularly true for fiber optics as its capabilities and state of development for wide band service is not fully appreciated. Therefore, steps should be taken to assure that HDTV will take full advantage of fiber optic technology.

We recommend the adoption of a terrestrial broadcast HDTV standard. We also recommend that standards for the interconnection of alternative media to the terrestrial broadcast system be adopted.

Furthermore, we urge that consideration of national HDTV competitiveness include fiber optic transmission and distribution as they relate specifically to HDTV. Finally, we recommend that regulations affecting the free exchange of HDTV related research and development information be eased.

## BACKGROUND

With fiber optic technology, the electronic broadcast signal is transformed from electrical to optical form at the originating facility, transmitted by fiber cable to the receiver location, and then reconstituted as an electrical signal.

Fiber optics is now widely used for long distance telephone transmission. Furthermore, the first transatlantic optical fiber system has been successfully installed and tested. Fiber optics is also being used for a variety of video and computer applications.

In 1989, there will be a national field trial of a land-based fiber optics broadcasting network. Participating will be seven regional Bell companies, five interexchange carriers, twelve manufacturers and five broadcasting networks. The trial will employ video compression techniques that could lead to the widespread use of optical fiber for the transmission and distribution of NTSC video and open the way for High Definition Television. Bell South broadcast portions of the Democratic Convention with high definition over fiber optic cable last summer and Southwestern Bell recently carried the broadcast of a major league baseball game via fiber optics to a nearby theater in St. Louis.[1] An NTSC video fiber-to-the-home system is in operation at Hunter's Creek, a development near Orlando, Florida.

## BENEFITS OF FIBER OPTICS TO HDTV

Studio equipment is now available to produce pictures with 525 progressively scanned lines (or 1050 lines, 2 to 1 interlace) and 16:9 aspect ratio. Such systems use 30 megahertz of bandwidth for each signal component (color) or 90 megahertz total. Effort is now ongoing for the development of a studio standard.

Spectrum availability limits the bandwidth per channel available for terrestrial broadcast. The FCC is working with industry through its ATV committees to develop a terrestrial broadcast standard which meets the severe bandwidth limitations imposed on spectrum availability. HDTV terrestrial broadcast would use 90 MHz if completely uncompressed. However, the FCC plans to restrict

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[1]International Competitiveness Study of: The Fiber Optic Industry U.S. Department of Commerce (ITA) September 1988

bandwidth to 6-12 MHz. Because fiber does not suffer similar limitations, it can be used to provide HDTV with a higher quality of presentation that can contribute to its success. In fact, the most significant advantage of fiber transmission lies in the information capacity or bandwidth that can be accommodated. Using optical fibers, wider band systems can be built to transmit images to the limit of the human eye.

The highest quality HDTV reception will be realized through digital encoding of the signal and transmission to the receiver with as little compression as possible given the transmission medium. With a fiber medium, it is feasible to provide a modestly compressed, digitally encoded signal with full quality resolution, color, and motion. A bit rate of 600 Mb/s,[2] is well within the capability of present fiber systems which would allow for the full capability of HDTV technology to be realized without significant compression degradation.

Another important advantage is that the signals can be transmitted over fiber for greater distances with fewer repeaters than with coaxial cable, yielding higher quality and lower cost systems. Furthermore, single mode fiber is bi-directional permitting the consumer to communicate directly with the organization providing the service for program selection options without the need for additional cable.

The advantages of fiber optic transmission and distribution of HDTV signals can be summarized as follows:

Superior Picture Quality

Fiber optic systems are immune to external interference and offer wide bandwidth. As a result, more signal information can be sent and noise suppressing bandwidth expansion employed.

Maximum Channel Density

The wide bandwidth of optical fibers allows a large number of channels to be multiplexed on a single fiber. Furthermore, the small diameter of optical fibers allows many fibers to be incorporated in compact cables.

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[2]Bit rates now being considered for fiber are in the order of 120 to 150 Mb/s. The lower rates would require additional signal compression, but still provide high quality and resolution. Also, 150 Mb/s would be compatible with the new SONET standard for digital transmission over fiber.

Conservation of Broadcast Spectrum

Fiber networks eliminate the need for additional use of the broadcast spectrum. If all users had access to a fiber network, scarce broadcast channels could be reallocated to other services such as mobile radio.

Ease of Future Enhancements

Because fiber is a closed medium offering high channel density, additional channels can be allocated as needed.

Analog and Digital Operation

Traditionally, digital transmission has been used with optical fibers because of their wide bandwidth. Recent laser advances make possible their use with existing analog formats.

Compatibility with Telephone and CATV Networks

The telephone network has been switching to digital transmission while CATV has remained analog. Fiber optics can transmit both types of signals.

Because of these specific characteristics, fiber optics can be used to great advantage with any of the formats being used or considered for broadcast, cable and telephone.

## BENEFITS OF HDTV TO FIBER OPTICS INDUSTRY

Fiber optics is a U.S. domestic industry embracing over 700 companies. HDTV will benefit this industry by opening up a new market particularly well suited to a fiber transmission medium. Manufacturers of fibers, cables, connectors, transducers, and test equipment will benefit through increased sales as the advantages of fiber are realized and the transmission systems are brought closer to the home.

In telecommunications most of the long distance lines in the continental U.S have been converted to optical fiber. One of the next large markets lies in the short haul distribution. HDTV will accelerate growth through its need for greatly increased signal capacity which can most efficiently be provided through a fiber optic medium. Together, HDTV and fiber to the home can provide major growth to the fiber optics market in the mid 1990's and beyond. Increased opportunities for the use of fiber optics for transmission and in studio applications will also be afforded.

The present U.S. market for fiber is approximately $1 billion, but with the movement of fiber into local area networks and the subscriber loop it could well be $2.5 billion by 1995 and a $4 billion market by 2000.

## APPLICATIONS

The total HDTV system includes broadcast video services, video coding, long haul transmission, local distribution and the receivers. The various alternatives for each of these functions are shown in Table 1. Currently, long haul transmission is primarily achieved by satellite and distribution by analog coaxial cable and terrestrial broadcast. Additional alternatives will be employed in the future including the use of fiber optics in both digital and analog formats for transmission and distribution.

The successful implementation of HDTV will require the use of a variety of transmission systems. Optical fiber will be employed at several network levels for HDTV. There is a pressing need to upgrade the quality of CATV systems; fiber is already being used for this purpose. With HDTV, not only will quality be a concern, but additional capacity will be required for either the wider or additional channels that will be necessary. The requirements for higher quality and more capacity extend beyond the trunk plant all the way to the home. Fiber will be used both to upgrade present systems and as a basis for new systems. Capabilities for nationwide transmission of HDTV programming are limited. Fiber offers a long distance wideband medium capable of fulfilling this need. Similar considerations apply to studio, to transmitter links, and to the studios themselves.

The diversity of the U.S. video service industry has resulted in a complex system with a large number of transmission media interfaces. In order to implement a high quality system as rapidly as possible, a large number of media interconnection issues must be resolved. It is important that these issues be made an integral part of HDTV system development and standardization. Cooperation between manufacturers will be required. Relaxation of anti-trust regulations is needed to maximize cooperation and permit joint developments.

TABLE I

Television System Components

| Broadcast Video Sources | Video Coding | Long Haul Transmission | Distribution | Receivers |
|---|---|---|---|---|
| Live | Analog NTSC | Microwave | Analog Broadcast | NTSC TV/VCR Analog Input |
| Film | Digital "NTSC" | Digital Fiber Optics | Analog Coax | "NTSC" TV/VCR Digital Input |
| Tape | Analog HDTV | Satellite | Analog Hybrid Fiber/Coax | HDTV TV/VCR Analog |
| | Digital HDTV | Physical Transfer | Digital Coax | HDTV TV/VCR Digital |
| | | | Digital Fiber | |
| | | | Physical Transport | |

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## CONCLUSIONS AND RECOMMENDATIONS

The Division firmly believes that fiber optics will be important to the development of a strong domestic HDTV industry. This includes fiber for long distance transmission, distribution trunking and ultimately to the home. This belief is based on the bandwidth required for HDTV. In addition, fiber facilitates HDTV quality due to its noise immunity, reduced requirements for amplifiers, and freedom from multi-path interference and rain attenuation.

Conversely, HDTV definitely will cause an increase in fiber optic deployment. Fiber optic television distribution systems are already being deployed by telephone companies and CATV system operators.

Successful implementation of HDTV will require a system approach. Origination, transmission and receiver issues must be treated together.

The division believes that the following actions are needed at the earliest possible time to support the development of a strong domestic HDTV industry:

1. Adoption of terrestrial broadcast standards for HDTV;

2. Concurrent adoption of standards for the interconnection of alternative media to the Terrestrial Broadcast system;

3. Expansion of National competitiveness considerations to include fiber optic technology specifically related to HDTV;

4. Relaxation of anti-trust regulations affecting the free exchange of research and development information among entities providing components and systems necessary for the overall deployment of the HDTV system.

Mr. WALGREN. Thank you, Mr. Berge. We appreciate that statement.

Here we have Mr. Berge talking about lightwaves, Mr. Fluke talking about electronic measurements, Mr. Hughes talking about sensors and nondestructive sensing systems, I gather; Dr. Kaufman talking about chemical purity factors.

It seems this measurement thing seems to elaborate exponentially. I guess, as you would expect, I guess it should follow that the budget, if we are to perform these functions governmentally, the budget of something like the Bureau of Standards should also elaborate to support those functions.

And I guess what I'm sensing is do you agree that we should look at the budget of the Bureau of Standards as very different from the budget of other government agencies? Where we might expect a function to be performed and not need substantial increases by the nature of the enterprise in the Bureau of Standards?

We must multiply and we must proliferate and provide the resources to do that.

Does anyone want to comment?

Dr. KAUFMAN. Some words like, first of all, there's a maintenance need, there's a diversity need, and there's an intensity need. This to some degree you also see the price of success as the applications become more relevant, more obvious or whatever, the needs become greater as well.

If NIST were operating in a vacuum and the work they were doing were what we would call purely academic with no relevance, we wouldn't have this problem. That's the problem of success.

Mr. WALGREN. I guess what I'm looking for is, from your perspectives, is there an inherent legitimacy of expanding budgets in the NIST because of its function in measuring and because its purpose is to provide ever-expanding capabilities of measurement?

Mr. BERGE. I don't know that in the case of lightwave measurement that it's been expanding exponentially.

Mr. WALGREN. But there was a time when lightwave measurement wasn't there.

Mr. BERGE. That's true, but then we were a new industry. I think that these projects that have been singled out, as in the NIST bailiwick, have been there all along. I think that they have been frustrated in the amount that they can obtain year to year and have done the basic work that needs to be done, and sees this work ahead, which is essential to the growth of the industry. And they would like to become more involved and be more helpful.

Mr. WALGREN. Any other quick comments? I don't mean to take the time.

Mr. HUGHES. Perhaps one method of thinking about it might be that in the development of a brandnew sensor, just developing the sensors is just the start of the process. I think the technology part that's now in NIST as a key part, how do we, an industry, actually take that device and make it work. I would see that as a continuum. And that's the point at which funding really has to be accelerated, taking lab work and going through the pilot stage.

There's an order of magnitude difference in funding.

Mr. FLUKE. The act of creating measurement standards inherently involves the creation of a lot of technology that heretofore did not exist or did not exist in any practical form.

There's a peculiar thing about the National Bureau of Standards laboratories that is quite unlike most other government laboratories and, for that matter, most other university laboratories. That is the mobility of people back and forth across the industry laboratory boundary.

I think, at the moment, there are some 800 scientists in residence at the NBS labs around the country that come and go. And they feel they've gone as far as they can in understanding the technology for their particular and peculiar application back in their company, they take that knowledge, get up and leave with the NBS's blessing and a wish from the NBS to see them again sometime.

The fact is that an awful lot of industry is driven by discoveries that have come about by virtue of the National Bureau of Standards laboratory group having developed a measurement of measuring to an acceptable level of uncertainty, some physical quantity.

It's a marvelous source of technology that, unfortunately, now has drifted off to other nations, and now those other nations are benefitting by this marvelous source of technology.

Mr. WALGREN. The gentleman from California, Mr. Brown.

Mr. BROWN. Pass, Mr. Chairman.

Mr. WALGREN. Mr. Skaggs.

Mr. SKAGGS. Thank you, Mr. Chairman.

I would appreciate, as a layman with only modest scientific background, if I could get a better grasp of some of the concrete examples of potential improvements that each of you have talked about.

For instance, in the case of Mr. Fluke, what does it mean, what is the practical significance of achieving a lower level of uncertainty in the areas that you are talking about?

What can we do differently and better?

Mr. FLUKE. Well, I think maybe an example that's close to home, and in the newspapers all too often at the moment, are things that go wrong with airplanes. Certainly, a lot of what happens is personal pilot error, but when a cargo door blows off that old 747, that was not necessarily a pilot error so much as it was somebody else's error as to what causes that.

It has yet to be determined in that particular instance, but it is clear that the efforts on the part of industry make machinery run longer with less maintenance and perform more reliably under increasingly difficult conditions is what's driving the need for more and more accurate standards to, in turn, drive all the instrumentation between our primary standards in places like Boulder and Gaithersburg and out there on the factory floor of Boeing where they're drilling holes in wing spars and wing skins in preparation for riveting them.

Something as obscure and maybe even seemingly mundane as measuring the surface smoothness of the interior bore of a hole through which a rivet will now go might well determine how long that rivet will last. The notch stress that can occur as a result of roughness in the bore of the hole.

At the electronic extreme on the other hand, if you're relying on a radar altimeter that was to be taken out of a plane in Alaska that came down through Seattle to pick you up and then flew to Denver some place, you'd like to know that that radar altimeter was calibrated against standards that are common between whatever it was in Alaska and whatever they think the altitude of the terrain around Denver is.

The water meter on the side of your house may only be an accurate plus or minus 3 percent, but when you multiply it by millions and take the uncertainty in that system and go back up through the process of calibrating those water meters, you can well imagine the public/private electric utilities really going out for rate increases they don't need because their meters aren't charging enough. Or making or taking in more dollars from the consuming public than they should because the meters are wrong.

The other way, in the aggregate, what is going on here is everything is getting tighter. The Japanese bring us automobiles that break less often, are good the first time out of the box, so to speak. You can trace a lot of that reliability back to things like surface smoothness. The smoother the surface in a mechanical bearing, the longer the bearing will last, the smoother it will, the quieter the car will be and so forth.

All of these things impact in ways that we hardly ever think about our ability to compete with foreign sources of products that are brought to our shores and, of course, the ability of the products we produce on our shores to compete abroad.

Quality is a much over-used word, but it nonetheless is the basis for a lot of competitiveness. And the Japanese had a horrible currency relationship with the United States and the darned guys are still winning. Well, they actually lost World War II, but this time they got Detroit without firing a shot and they're still winning, even though their currency over the last three or four years has doubled relative to the U.S. dollar.

And it's because the American public, like most consumers around the planet, have a preference for high-quality goods. And, I mean, the only way you could tell of the existence of the NBS is that it wasn't working.

It's one of those things that when it's working fine, it goes absolutely unnoticed. But we're getting close to the edge, or we have gone over the edge in many cases, and it's damaging U.S. industry.

Mr. SKAGGS. Those are very helpful to me. I hope, for the record, as well and in convincing colleagues of the importance of what we're trying to do here, maybe Dr. Kaufman, if you could pull out similar kinds of instances of what we get being able to achieve one part per trillion versus one part per billion in the chemical industry, what difference does it make in something I can talk to my wife about.

Dr. KAUFMAN. You're probably better off talking to your wife about something else. [Laughter.]

Mr. SKAGGS. We have a different relationship.

Dr. KAUFMAN. If she's interested in micro-electronics, as some wives are, here's the perfect case of an industry that's very much concerned with how much metallic impurities are in the chemicals that they process, or that they use for processing.

So that example I gave, 10 parts per million, or a part per million, was fine in terms of processing chemicals 10 or 12 years ago. Now, we have to talk in terms of 10 parts per billion.

And in some cases, as I said, parts per trillion, these are, as I said, grains in a pool that has 500,000 gallons of water in it.

What's the problem?

The problem is that these metallic impurities affect the integrity of the devices and as we try in our competitive way to achieve in our devices—we're in the megabyte area now on devices, very narrow dimensions—lesser and lesser amounts of metallic impurities. And these can be common ones—iron, sodium, transition metals. These impurities deleteriously affect the integrity of the devices, which is what you don't want.

And of course the yields as well. So you have a double whammy there. As we're pushing the frontiers on these micro-electronic devices, we need a way of measuring these impurities. We need chemicals that have these low quantities of metals in them. It's critical.

Mr. SKAGGS. We're talking about things like etching the circuitry on a chip and the impurities that can get in the way of that process.

Dr. KAUFMAN. Exactly. Largely, in the photo-lithographic process, which is our experience, and it's a competitive issue, there should be, from a national standpoint, companies in the United States that can provide our domestic industry as well as from an export basis to help the balance of payments, companies outside of the United States.

But, from a national security standpoint, American companies need to fill this demand for our own micro-electronics industry. This is why I feel very strongly that NIST is playing an important role. But the challenges are greater and greater as you're pushing to find that grain in the swimming pool or that fraction of a grain in a swimming pool.

But, these are real. These are important. They affect the device integrity.

Mr. WALGREN. If the gentleman would yield, what happens is the metal isn't smooth enough. The washer stops in the middle of the spin cycle. Then the clothes are full of water and you can't wring them out.

Mr. SKAGGS. Let's not patronize my wife. [Laughter.]

Mr. WALGREN. That's personal experience.

[Laughter.]

Mr. SKAGGS. I appreciate the answers, but it's that kind of specificity and practical significance of this that helps us in our job, or at least me in my job enormously.

Thank you, Mr. Chairman.

Mr. WALGREN. Mr. Boehlert.

Mr. BOEHLERT. Thank you, Mr. Chairman.

Just one general question for all of you. You're engaged in preaching to the choir. We're a sort of professional cheerleading squad, NIST. We authorize. We don't always get the appropriations we would like to get, and we're not always successful in convincing our colleagues that we should give as much as we would like to give.

Not always on the plus side of the ledger if you were looking to prioritize and you had at the bottom of your list some areas where we should have less concentration in order that we might have more funds for greater concentration in other areas, what would you choose?

Mr. FLUKE. Let me take a shot at that impossible question.

I guess I would choose to leave those things on the agenda for NIST's metrology function that have great merit.

Now that's a trick answer to a legitimate question. How do you determine what has merit?

The answer I think, as you look around for what industry needs, who from industry steps forward with what sets of problems and let that guide what's going on. That essentially has been the history of the National Bureau of Standards and it has worked very well.

To attempt to legislate what should get funded and what should not is a big problem. So, therefore, what you are left with is trying to establish some rational level of total appropriations and leave it to the interaction between NIST and industry through mechanisms that have demonstrated that they work very well.

Let those mechanisms determine where the funding is applied. Obviously, there's got to be something of a bottom/up generation of those numbers. You don't know how much to appropriate in any event.

I can assure you that what is in the cards at the moment is woefully inadequate from the years 1973–87. NBS funding for these initiatives has been basically flat—so slightly down.

In absolute numbers it is very bad news. In the same period of time, industry-funded private research and development has more than doubled. So we've got a big problem here that needs fixing as to how you go about getting the money.

The other question is:

Where is the money going to come from?

It would be interesting for you maybe to go back and review some work done on an amendment to the 1986 Armed Services appropriation bill done by Congressman Kasich and Senator Levin. This was a piece of legislation passed that required the DoD to have a preference for the acquisition of commercial products wherever possible.

The numbers that were used in processing that amendment, that piece of legislation, said that the DOD was procuring about $180 billion a year worth of stuff, and of that $180 billion, $60 billion could have been almost outright commercial products instead of development items.

Now, as to exactly what the savings might be if that $60 billion were to be commercial products, that is to say, where the DoD did not have to pay any development costs at all, and, in fact, would probably get a better product the first time around, it is quite possible that more than half of that $60 billion would have been saved.

Now it turns out that the legislative initiative was vastly easier than the regulatory phase. I mean, you get into the federal acquisition regulations and get things tweaking, you know, you folks here are on the board of directors of the free world, which is what Congress is.

You are parties here who receive an impediments report from the DoD. And this will presumably give you insight, among other things, into which Federal acquisition regulations are in the way where commercial products would be more than satisfactory to do the DOD's job.

I don't know if you've ever seen such a report in committee. I think there's been some attempt at delivering it. But there's a giant source of money that I think Congress in general is in the process of tapping, in any event.

As I travel around and see our customers, some of whom are military and aerospace prime contractors, the most frequently heard word is downsizing. People by the thousands are being discharged from these firms because the days of the old cost plus approach are gone. That's at least one source of money for what amounts to—I don't mean to call a few hundred million dollars peanuts, but by the same token, there is that kind of money available from other segments of government spending.

And I think the nation, Congress and the Administration are all concurrently in a mood to go and get some of those dollars.

And the question is: Where might you put them?

My answer to that is that we need to be careful as a country to rebalance the spending we do between sort of internal transfer payments between segments of our population, something we have to do that's part of circulating the dollars around the economy for the maximum benefit of everybody. But a dollar once gone around this economy four, five or six times, it's pretty well worn out and we need some new dollars from some place. We need those dollars from our trading partners and, therefore, we need a lot more thought on the subject of offensive measures that we might take in the public policy arena rather than too much in the way of defensive measures at the expense of offensive measures.

That's why what's incredibly difficult to explain, I can assure you, that a National Bureau of Standards, or NIST, with perhaps double the level of funding they presently have is an incredibly important implement to going and crushing the bones of a few of our competitors offshore.

My dad used to like to say, he started the Fluke Co., and he used to like to say: "The only good competitor is a dead competitor."

Unfortunately, you're not allowed to go around and shoot them, so the way you kill them is by out-doing them on behalf of the customer. That's ever truer when you go abroad.

We have to have the best product. We have to prepare it properly for the overseas market. And the first of those two items is best done by basing the product on the latest practical technology and NIST, as I mentioned earlier, is a marvelous source of such technology.

Mr. BOEHLERT. I agree with all of what you said, but you haven't made my job any easier. [Laughter.]

Would anyone else care to address the question?

Do you see any areas where we might be able to affect a savings so we could redeploy those savings to areas that we need a greater concentration?

Mr. Berge.

Mr. BERGE. This might be related, Mr. Boehlert, but somehow I wouldn't want to take any money away from the fiber optics. However, I know that there is additional funding required, especially for NIST's new mission of technology transfer and the technology center's investment.

I think that's also essential. And I think that money's got to come, but I certainly don't think it should come from the metrology and the light-wave.

Mr. BOEHLERT. It should come from outside.

Mr. BERGE. It's additional funding that's required to do a mission. If it's in the mission, it should be funded.

Mr. BOEHLERT. I'm wedded to those new missions, so I'm going to try to fund it.

Let me ask you while I've got you, Mike, what's your view as to how this and DoD are inter-related, cooperating on electronics?

Mr. BERGE. We in the Fiber Optics Division of TIA are very much involved in standard setting to DoD. It's part and parcel of that effort. They've been directed to use our standard where possible. They're serving on our committees. We're producing standards and giving it to them, the Defense Electronic Supply Center, and we process them around within DoD and even adopt them.

We've had many of our test procedures and now even our specifications being adopted by them. DoD doesn't drive the Fiber Optics Division in Telecommunications; they only have about $162 million out of a total billion dollar market. They are very big in the sensor area. We're becoming more active in that sensor area, so there's a trade-off back and forth.

We're doing more efforts, creating a Sensor Standards Committee, and we're working more closely with them in that. So, back and forth, we're working with them within TIA and within DoD.

Mr. BOEHLERT. Thank you.

That's all, Mr. Chairman.

Mr. Skaggs [presiding]. Thank you very much for joining us this morning and we appreciate your testimony and advice. We're considering the Lombardi-Fluke Trophy. [Laughter.]

Thank you, gentlemen.

Our next panel, and concluding panel for this morning, Mr. Christopher Coburn, Science and Technology Adviser to the Governor of Ohio; and Mr. John Kincaid, Executive Director of the Advisory Commission on Inter-Governmental Relations.

Gentlemen, your full statements will be made part of the record. If you would care to summarize those statements for us, then we'll get into some exchange.

Mr. Coburn.

## STATEMENT OF CHRISTOPHER M. COBURN, SCIENCE AND TECHNOLOGY ADVISOR TO OHIO GOVERNOR RICHARD F. CELESTE, NGA LEAD GOVERNOR ON SCIENCE AND TECHNOLOGY

Mr. COBURN. I'm Chris Coburn. I direct the Ohio's Thomas Edison Program, which is a $250 million public/private partnership, which is one of the largest university-industry programs in the nation.

I'm here in that capacity as well as my capacity as staff chairman of the National Governors' Association Working Group on State Initiatives in Applied Research.

Before coming to the Clearinghouse, I think it's important to review the thinking that originally led to its creation.

In December 1986, the Washington Post wrote that upheaval is occurring in the way America is learning to compete economically in the world. The Post noted, this upheaval was rarely recognized inside the Beltway because it was not the product of Washington wizardry. This activity was occurring in the States largely in response to the painful economic transition of the early 1980s; States began to institute their own economic competitiveness initiatives.

States set out to maximize their native resources and direct them toward the world marketplace. The core of these efforts were programmed similar to those in Japan and western Europe, which you will have discussed earlier today, linking academic and industrial bases; just as Japan has MITI and Germany has the Fraunhofer Society, the 44 States now have Applied Research and Economic Competitiveness Programs.

In fiscal year 1988, these States spent more than $588 million. In Ohio, this translates into a program with nine applied technology research consortia, over 110 seed capital grants and a statewide technology extension service.

I distributed some materials on our program which I think conveys the breadth of our activities in the State.

In creating the Clearinghouse, the Congress noted that these State programs fill a special need in the Nation's science enterprise. You were not alone. In a recent interview, Frank Press, President of the National Academy of Sciences and Science Adviser to President Carter, said that the States have been leaders in establishing university/industry partnerships.

Press believes that the State activity shows a greater awareness of the way the world is going than in many places in Washington.

The States are, according to Press, where the action is in many key sectors. States are almost exclusively funding applied research—you all talked about this point this morning—while most federal-civilian nonspace research is basic research.

Despite these differences, the economic goals at the State and federal levels of supporting research are the same.

We want to fund the best research that has the greatest economic return. The best way to achieve that goal is by working together.

The Clearinghouse is the tool which can ensure that state and local practitioners are provided the best information available. It can mean better leveraging of funds, greater opportunities for cooperative ventures and more rapid sharing of new ideas and programs.

The Clearinghouse can seek to become the accepted primary information source on state and local initiatives so that program administrators at all levels of government can be assured that they have used public sector resources as efficiently as possible.

The Clearinghouse can eliminate areas of potential conflict as well as cooperation and give earlier warning of these conflicts to permit constructive solutions.

The States' economic competitiveness programs have been cooperating together for a number of years. In late 1985, Ohio Gov. Richard F. Celeste through the National Governors Association established a Working Group on State Initiatives and Applied Research.

The Working Group was created to establish a forum where state officials could share experiences and learn from each other and provide a vehicle for speaking directly and clearly to the federal agencies and Congress on issues surrounding the state programs.

Its many accomplishments are highlighted in my prepared remarks. One of the recent accomplishments of the group is the letter that's attached that was recently sent to the President.

The Working Group has also noted over the years several areas of significant concern. One, the continuing evolution of more than 500 state and local programs has made it difficult, if not impossible, to adequately grasp the scope and nature of the investments being made. And, two, the lack of an accepted central reference point has allowed federal program administrators charged with establishing research commercialization programs to overlook existing state and local initiatives.

This also includes activity at the federal laboratories.

Three, government/university/industry partnership programs are springing up in almost every federal research agency. There is no way for states, or really anyone else, to accurately monitor these changes.

Thus, states can neither effectively participate in these partnerships nor access the federal research dollars these partnerships redirect.

Congress addressed the States' concerns in the Trade Act in laying out the mission of the Clearinghouse. The language is clear. The report states:

> The primary purpose of the Clearinghouse is to assist State and Local government agencies to learn from the creative initiatives of other State and Local governments. In addition, information on these initiatives can help ensure that federal programs complement rather than hinder or unnecessarily duplicate state and local efforts.

Unfortunately, it seems to us in the States that despite the best of intentions, the initial direction of the Clearinghouse has strayed from the Congress' intent.

If the Clearinghouse is to be successful, it needs to have realistic, achievable goals that directly reflect its original mission. Among the points for the Committee to consider are:

One, maintain a clear focus. For $250,000 a year, or even a million dollars per year, the Clearinghouse is not to, as one consultant suggests, improve the standard of living for all Americans. It does, however, have the chance to fill a very real void in the Nation's science enterprise.

This can only be done with a realistic, informed strategy which can be implemented quickly and successfully.

Two, take direction from constituent groups. A formal or semi-formal board should be set up to advise the Commerce Department on the operation of the Clearinghouse. This board should include state and local science and technology program directors.

Effective communication might also be achievable through a formal link with the NGA, with the National Governors' Association.

I have to say that commendable efforts have been made so far in this direction, but those efforts need to be more focused and made more direct.

Three, resist the temptation to broaden the role of the Clearinghouse. Some organizations have suggested that the Clearinghouse should include a service where individuals and businesses could call an 800 number and gain information on State programs. Let's think about that for a second.

A company in a State—let's pick any State in the country—California—is going to pick up the phone and call Washington to find out about services in their own State.

I guess the question that raises for me:

How is that company going to find out about that 800 number without the Federal agency advertising and, in some way or another, suggesting to this company that this is the right course of action.

If that is the way it were to be done, I would observe that that advertising, that effort on the part of the federal agency, is going to be in direct competition with the State's own efforts in its own State.

And I think the goal here, recognition by the Committee and by the Congress, is the fact that the States are the primary deliverer of these services and we're trying to build off of that rather than supplant them.

I think that's an area for real concern.

In creating the Clearinghouse, the Congress has taken a specific action to recognize that State and local initiatives are unique and they are meeting the needs of American businesses in a way no one else is.

The federal government needs to recognize the special role of the state and local programs and try to take advantage of them, not supplant them.

The concept should be that the States are the retailers of information and services and that the Clearinghouse is the wholesaler to the state and local government.

The fourth point is the Clearinghouse needs to build off of others' work, other organizations, activities in this area—the National Governors' Association, the National League of Cities, the National Science Foundation—have all done excellent work in collecting the information and distributing it appropriately.

But there is still a very major need to tie that information together and put it in one place where it can be accessed directly.

Finally, my last point is, five, there is a need to provide information for high-priority Federal programs. Among the programs that can be addressed here are the SBIR program, the federal matching program where a state match is expected.

Every one of these programs has a certain informational need that if the States can't access that directly really puts one state behind another in terms of its ability to effectively participate in the Federal programs.

And I think, in the end, exacerbates the problem of regional allocation of federal research dollars.

I've covered these points in my prepared remarks.

Finally, to conclude, the creation of the Clearinghouse was much needed. It offers genuine promise for improvement in an area critical to States, as well as the federal government.

Unfortunately, unless it is administered with inspiration and insight, it could entirely miss the goals laid out by Congress.

The Committee needs to evaluate how the Clearinghouse can most effectively meet its mission given the limited resources available. Clearer and probably more modest goals will be spelled out.

Again, for instance, the NGA has been—I'm sorry—appropriate organizations, including the NGA, the National Governors' Association, and the National League of Cities, should be deeply involved in operating the Clearinghouse.

And as I said earlier, these organizations have been very active in these areas. A critical issue for the successful operation of the Clearinghouse will be its ability to maintain accurate and up to date information. Organizations with established ties to the state and local officials responsible for these initiatives are in the best position to obtain such information.

It is very important that the Clearinghouse support the existing networks rather than create a competing one.

Finally, the state and local initiatives have initially succeeded largely in spite of federal agency indifference. State and local programs can with tools like the Clearinghouse bring a new level of vigor to the Nation's research enterprise.

In closing, I want to thank the Committee for giving me this opportunity to comment on this important subject. And, again, to commend all of you for creating the Clearinghouse.

Of course I'll be open for questions.

[The prepared statement of Mr. Coburn follows:]

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STATEMENT OF

CHRISTOPHER M. COBURN

SCIENCE AND TECHNOLOGY ADVISOR TO

OHIO GOVERNOR RICHARD F. CELESTE

NGA LEAD GOVERNOR ON SCIENCE AND TECHNOLOGY

before the

SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY OF THE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

UNITED STATES HOUSE OF REPRESENTATIVES

ON

THE CLEARINGHOUSE FOR STATE AND LOCAL
INITIATIVES ON PRODUCTIVITY, TECHNOLOGY,
AND INNOVATION

MARCH 8, 1989

## INTRODUCTION

Mr. Chairman and members of the committee, thank you for inviting me to testify today. My name is Christopher Coburn and I direct Ohio's Thomas Edison Program, a $250 million public/private partnership that is one of the largest university/industry programs in the nation. I am here also in my capacity as staff chairman of the National Governors' Association Working Group on State Initiatives in Applied Research, a position I have held since 1985.

I have been asked to comment on the effectiveness of the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation, which was established in the Department of Commerce with the enactment of the Omnibus Trade Bill in 1988. Before commenting on the clearinghouse, I think it is important to review the thinking that originally led to its creation.

## BACKGROUND

In December 1986 The Washington Post wrote that "an upheaval is occurring in the way America is learning to compete economically in the world." The Post noted that this upheaval was rarely recognized inside the Beltway because it was not "the product of Washington wizardry." This activity was occurring in the states. Largely in response to the painful economic transition of the early 1980s, states began to institute their own economic competitiveness initiatives. States set out to maximize their native resources and direct them toward the world marketplace. At the core of these efforts were programs, similar to those in Japan and western Europe, linking academic and industrial bases.

Just as Japan has the Ministry of International Trade and Industry (MITI) and Germany has the Fraunhofer Society, forty-four states now have applied research and economic competitiveness programs. In fiscal 1988 these states spent more than $550 million on these efforts. In Ohio, this translates into a program with nine applied technology research consortiums, over 110 seed capital grants, and a statewide technology extension service.

In creating the clearinghouse, the Congress noted these state programs fill a special niche in the nation's science enterprise. You were not alone. In a recent interview, Frank Press, president of the National Academy of Sciences, and former science advisor to President Carter, said in many ways the states have been leaders in establishing university/industry partnerships. He believes that the state activity shows a greater awareness of the way the world is going than many in Washington understand. The states are, according to Dr. Press, "where the action is in many key sectors."

States are almost exclusively funding applied research, whereas the majority of federal civilian non-space research is basic research. Despite these differences, the economic goals at the state and federal levels of supporting research are the same — we want to fund the best research that has the greatest economic return. The best way to achieve that goal is by working together.

The Clearinghouse for State and Local Initiatives on Productivity, Technology and Innovation is a tool which can ensure that state and local practitioners are provided the best information available. It can mean better leveraging of funds; greater opportunities for cooperative ventures; and more rapid sharing of new ideas and programs. The clearinghouse can become the central repository for information on state and local initiatives so that program administrators at all levels of government can be assured they have used public sector resources efficiently. The clearinghouse can illuminate areas of potential conflict as well as cooperation, and give earlier warning of these conflicts to permit constructive solutions.

The states' economic competitiveness programs have been cooperating together for a number of years. In late 1985, Ohio Governor Richard F. Celeste, through the National Governors' Association, established the Working Group on State Initiatives in Applied Research. The working group was created to address two critical needs:

1. establish a forum where state officials could share experiences and learn from each other; and

2. to advise the NGA Committee on Economic Development and Technological Innovation on state-federal issues in science and technology.

The working group, composed of Governors' science and technology advisors and state program administrators, has met both of these goals. Accomplishments of the working group include an unprecedented cooperation agreement with the National Science Foundation and nationwide conferences on technology development programs. One recent activity was the development of recommendations included in the attached letter to the President that attempts to spell out the role of the states in U.S. technology policy. In its deliberations, the working group has noted other areas of significant concern:

1. The continuing evolution of the more than 500 state and local programs has made it difficult, if not impossible, to adequately grasp the nature and scope of investments being made.

2. The lack of an accepted central reference point has allowed federal program administrators charged with establishing research commercialization programs to overlook existing state initiatives. This includes overlooking activity at the federal laboratories.

3. Government-university-industry partnership programs are springing up in almost every federal research agency. There is no way for states (or anyone else) to keep up with these

changes. Thus states can neither effectively participate in these partnerships nor access the federal research dollars these partnerships redirect.

The interest of Congress in these issues has been especially gratifying. The trade bill's legislative history on the clearinghouse addresses each of the states' concerns. The House report notes that:

> the primary purpose of the clearinghouse is to assist state and local government agencies to learn from the creative initiatives of other state and local governments. In addition, information on these initiatives can help ensure that federal programs complement, rather than hinder or unnecessarily duplicate, state and local efforts.

It seems to us in the states that the initial direction of the clearinghouse has strayed from the committee's intent.

Observations on the Clearinghouse

If the clearinghouse is to be successful it needs to have some realistic, achievable goals that directly reflect its original mission. Among the points to consider:

1. Maintain a clear focus. For $250,000 per year, or even $1 million, the clearinghouse is not, as one consultant suggests, going to improve the standard of living for all Americans. It does, however, have the chance to fill a very real void in the nation's science enterprise. This can only be done with a realistic, informed mission that can be implemented quickly and successfully.

2. Take direction from constituent groups. A formal or semi-formal board should be set up to advise the Commerce Department on the operation of the clearinghouse. This board should include state and local science and technology program directors. Effective communication might also be achievable through a formal link with NGA.

3. Resist the temptation to broaden the role of the clearinghouse. Some organizations have suggested that the clearinghouse include a service where individuals and businesses could call an "800" number and gain information on state programs.

   Think about that for a moment. In creating the clearinghouse, the Congress has taken specific action to try to build on state and local initiatives that it feels are uniquely meeting the competitive needs of American businesses. The tenet of this suggestion is that the federal government, rather than the successful state programs, will reach the companies in need in each state. The federal government needs to recognize the special role of state and local programs and try to take advantage of them, not supplant them. The concept should be that the states are the retailers of information and services, and the clearinghouse is the wholesaler of information to state and local governments.

4. Build on others' work. The clearinghouse will be far more effective if it builds on existing databases. Recent and ongoing work at the National Governors' Association, and the National Science Foundation's study on state R&D expenditures provide excellent vehicles.

5. Provide information for high priority federal programs. Another important function of the clearinghouse is to serve as "a central repository for information on federal efforts to assist state and local governments to enhance competitiveness." There are several types of information that would aid states in their technology development efforts. These include, for example, information on federal interdisciplinary research competitions — especially when state match is required — and data on the Small Business Innovation Research program (SBIR). Let me spend a moment on that program. The current multi-agency administration of the

SBIR program forces states to recreate actions that have already occurred at the federal level. When program solicitations are sent from the various federal agencies, states reenter the data from hard copy back to their own data bases.

It would be much more efficient if the clearinghouse were to gather data files from the eleven participating federal agencies, aggregate the data, and then make it available -- on disk -- to the states. More efficient access could help bring new participants into the SBIR program and could potentially address the regional disparity in allocation of the awards.

Conclusion

The creation of the clearinghouse was long overdue. It offers genuine promise for improvement in an area critical to states as well as the federal government. Unfortunately, unless it is administered with inspiration and insight, the clearinghouse could entirely miss the goals laid out by Congress.

The committee needs to evaluate how the clearinghouse can most effectively meet its mission given the limited resources available. Clearer and probably more modest goals need to be spelled out first. Second, appropriate organizations, including the National Governors' Association, should be deeply involved in operating the clearinghouse. The NGA, for example, has collected and published data on the following topics: the structure and function of state science and technology offices, state supported SBIR programs, and state competitive research grant programs. NGA currently is completing a comprehensive survey of technology extension services in cooperation with the National Institute of Standards and Technology. Similar [illegible]-ts are underway at local organizations, such as the National League of Cities, which has joined with the International City Management Association and the Government Finance Officers Association to form "Local Exchange," an information, research and communication network for the local government community.

A critical issue for the successful operation of the clearinghouse will be its ability to maintain accurate and up-to-date information. Organizations with established ties to the state and local officials responsible for these initiatives are in the best position to obtain such information. It is very important that the clearinghouse support the existing networks rather than create a competing one. As director of a state program, I can assure you that many groups send us questionnaires asking for information. We don't need to start up another surveyor.

State and local initiatives have succeeded largely in spite of federal government indifference. State and local programs can, with tools like the clearinghouse, bring a new level of vigor to the nation's research enterprise.

In closing, I wish the thank the Committee for the opportunitiy to discuss a program of importance to the states. I commend you for creating the clearinghouse, and I would be glad to try to answer any questions.

Mr. SKAGGS. Thank you, Mr. Coburn.
Mr. Kincaid.

## STATEMENT OF JOHN KINCAID, EXECUTIVE DIRECTOR, U.S. ADVISORY COMMISSION ON INTERGOVERNMENTAL RELATIONS

Mr. KINCAID. Thank you, Mr. Chairman, for inviting the Advisory Committee on Intergovernmental Relations to testify on this role, assisting the U.S. Department of Commerce to establish this Clearinghouse on State and Local Initiatives in Productivity Technology and Innovation.

My name is John Kincaid. I'm Executive Director of the Commission.

Last summer, as the Trade Bill was nearing enactment, the Department of Commerce asked our Commission for assistance in designing and installing the initial Clearinghouse data base and dissemination mechanism. The ACIR is an appropriate agency for undertaking this responsibility because the Commission has a nearly 30-year record of policy research and technical assistance in a broad range of State and local government issues, and with many national organizations representing those governments, as well as federal agencies.

The 26 members of the Commission as well constitute a broad cross-section of American Government representing the U.S. Congress and the executive branch as well as State legislators, Governors, mayors, elected county officials, and private citizens.

The Commission believes that it possesses the qualifications required to provide this assistance in a manner that will assure both technical competence of the product and widespread acceptance of the Clearinghouse by the respective users and information providers; by working closely with Commerce, we can develop a Clearinghouse that will be well-suited to the needs and objectives of business and the Nation's State and local governments.

The organizing principle we have proposed for the Clearinghouse is based in part on the concept of the telephone yellow pages. We developed this concept because there are many public and private organizations that provide information and assistance to those involved in efforts to improve technology and productivity and innovation.

In fact, we are still in the process of identifying these information providers and their services. These providers include federal agencies such as the Federal Labs Consortium the Department of Commerce itself, as well as many university-based technical information centers, state and local government organizations, public interest groups and private sector trade and industry associations.

The yellow pages approach to compiling and describing information available from these entities is a useful way to eliminate unnecessary duplication of services and to make efficient use of the taxpayer dollars.

This approach will allow the Clearinghouse to increase the visibility of existing sources of information, provide greater public access to existing resources, identify gaps where information is not readily available, and assist providers in filling those gaps.

The Clearinghouse, therefore, will not compete with these information providers by attempting to reassemble the actual data already available or replicating the existing surveys.

Instead, the Clearinghouse will lead users directly to the source of the expertise and assistance they are seeking.

The yellow pages concept is consistent as well with the Congressional mandate for the Clearinghouse to enhance the value of the information available about the nature, extent and effects of state and local initiatives.

As noted earlier, because the Clearinghouse would be in a position to identify areas where current information is lacking, it will also be able to encourage other organizations to fill those gaps and to improve the quality and recency of the data they collect.

In addition, the Clearinghouse will be able to fulfill an important analytical role by compiling information on how state and local governments assess their programs, an important service role, by putting people attempting similar initiatives in touch with one another so they can determine for themselves how well the innovations are working or will work in their other situations.

Perhaps, therefore, one of the most productive and innovative contributions that the Clearinghouse itself can make to this concept is to build upon and reinforce those services already being provided by private businesses, professional associations and federal, state and local agencies.

We believe developing the Clearinghouse along these lines will strongly encourage information providers not only to participate in the Clearinghouse, but also to improve their own services.

I have attached to this testimony, Mr. Chairman, an issues statement that explains our current thinking about the Clearinghouse in more detail. I would ask that this document be inserted in the record and would invite the Committee's comments on it.

Mr. SKAGGS. Without objection.

[The issues statement follows:]

ADVISORY
COMMISSION ON INTERGOVERNMENTAL RELATIONS
WASHINGTON, DC 20575

**ISSUES PAPER**

# Establishing a Clearinghouse for State and Local Initiatives on Productivity, Technology and Innovation at the U.S. Department of Commerce

This paper presents some background on the Clearinghouse for State and Local Initiatives on Productivity, Technology and Innovation authorized by the 1988 Trade Act for establishment within the Department of Commerce. The primary purpose of this paper is to set the stage for consultation and vigorous discussion among all interested parties-- those who would contribute information, those who would request it, and those who would be the Clearinghouse's principal beneficiaries--in the hope that they will guide development of the Clearinghouse so that it will be of greatest service.

After a brief review of the legislative history, the paper identifies potential users and uses of Clearinghouse information. The next section discusses the financial and technical constraints that must be considered when defining a role for the Clearinghouse. This is followed by a description of one possible model for the Clearinghouse that is consistent with and can operate within these limitations. Finally, the paper outlines what ACIR and the Department of Commerce believe is feasible to achieve with the Clearinghouse in its first year of development.

Listed on the last page are a series of issues of particular importance to getting the process of building the Clearinghouse underway. Comments from a diversity of groups and individuals are invited on these and on any other aspects of the Clearinghouse effort, and are considered an ingredient essential to the project's overall success.

**Legislative Intent**

That the authorizing legislation for the Clearinghouse appears as part of The Omnibus Trade and Competitiveness Act of 1988 serves to highlight the sense of urgency and concern that underlies its creation.

When Senator Dale Bumpers introduced the legislation to establish a clearinghouse, he cited the national uneasiness about declining American competitiveness abroad-- in both manufacturing and services-- and the lack of federal efforts to correct the problem. He pointed out that most of the bold and pragmatic strategies to counteract this trend are being pursued at the state and local levels where the effects of eroding competitiveness hit home, where necessity demands specific solutions to particular problems, and where ideological discussions quickly become irrelevant. The purpose of the Clearinghouse, he said, would be to help the state and local governments to learn from experiments which others already have undertaken, and to seek out the successful ones so that they can be replicated.

Specifically, the Clearinghouse is to serve as a central mechanism for making available information on (1) the initiatives of state and local governments to enhance the competitiveness of American business through the stimulation of productivity, technology, and innovation, and (2) federal efforts to assist state and local governments to enhance competitiveness.

The legislation enables the Clearinghouse to establish relationships with all levels of government; provide technical assistance; collect and disseminate information on the nature, extent, and effects of initiatives; disseminate information through reports, directories, handbooks, conferences, and seminars; enter into contracts for the collection of information; and develop evaluation methodologies. The Clearinghouse, however, is prohibited from evaluating individual state and local programs unless specifically requested to do so by the state or locality.

The Clearinghouse was established within the Office of Productivity, Technology, and Innovation (OPTI) at the U.S. Department of Commerce. OPTI has been incorporated into the Department's new Technology Administration.

A sum of $250,000 has been appropriated to the Department of Commerce for the Clearinghouse for FY88 and also for FY89, and a similar amount is anticipated for FY90.

Although the legislation is somewhat open-ended, it offers ample latitude in determining an appropriate Clearinghouse design, and an opportunity for those who can benefit most from the Clearinghouse to help define its content and objectives. The Department is committed to developing a useful and accessible

service in consultation with potential users and contributors of information.

The Department has enlisted the assistance of ACIR in designing an appropriate scope and role for a national Clearinghouse and in developing a systematic plan for the implementation of the design.

**Potential Uses and Users**

Some examples of state and local initiatives which may be of interest to Clearinghouse users include an agency in California which guarantees 85% repayment on bank loans to small companies that develop new exports, the Arkansas Science and Technology Authority which identifies and applies new technologies in partnership with industry, and the joint university and private sector efforts underway in many states to educate and train workers in new manufacturing techniques. An example of a federal initiative to assist states and localities is the effort currently underway by NIST-- the National Institute of Standards and Technology (formerly the National Bureau of Standards). NIST is working with several nationwide groups to promote the operation of state technology extension services for technology transfer. This effort was authorized by the same legislation that created the Clearinghouse and is designed to increase access to new technologies in parallel with the Clearinghouse effort to increase access to information.

However, it may not be desirable for the focus of the Clearinghouse to be strictly limited to federal, state and local initiatives such as these. Because the wording of the legislation is broad-- stressing productivity and innovation, as well as technology-- the concern of the Clearinghouse is not narrowly technical, but rather runs the whole gamut of the innovation process. Commercializing a technology can mean incorporating it into the manufacturing process, into the final product, or even into the delivery of manufactured goods to market. Thus, the scope of the Clearinghouse is potentially far reaching, touching upon such diverse areas as financing, testing, training workers, producing, distributing, marketing, and managing the quality of American products.

We can envision at least four classes of users of Clearinghouse resources. First among these are the small, medium, and large enterprises in private industry who will come with questions like, "Where can I get technical and financial assistance for developing my invention?". The second group of users are the program administrators and innovation center staffs actually involved in initiatives to help American business become more competitive. "We have a technical team to provide assistance in technology application," they may ask, "but how do we organize a



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revolving fund for venture capital to help small businesses get started?" Government organizations-- ranging in size from townships to states-- will constitute a third user group. They may have concerns about the health of their economic base, and may wonder, "What new industries can be homegrown if we invest in the new telecommunications infrastructure?" Finally, a fourth group will be policy makers in state governors' offices or legislatures, in federal agencies, or in the U.S. Congress itself. Confronted with limited funds and an abundance of programs, these users may ask, "How can we determine which of them is working?".

## Constraints on the Clearinghouse

The critical question is, given these parameters-- a mandate to focus on state and local initiatives, an array of potential users, and limited financial resources-- what unique product or service can the Clearinghouse bring to the marketplace?

There is no shortage of information on state and local initiatives. A large number of databases, surveys, and networks are provided by a variety of federal and state agencies, public interest groups, trade associations, and academic institutions. NIST in cooperation with the National Governors' Association, for example, is surveying states on the technical assistance they offer businesses. The Department of Trade and Economic Development in Minnesota recently revised its national compendium of state science and technology programs. Private firms have been active in data collection, as well. One recently completed a survey of joint state, university, and industry-funded Centers of Excellence, and another is surveying the best practices for encouraging technological innovation in the US and Europe. Also flourishing are membership groups, like the American Electronics Association, which collect and disseminate information about the activities of their members or the companies within their industries.

These efforts, and others like them, bear careful examination because they are important sources of information for the Clearinghouse and because their existence imposes certain constraints on what is an appropriate role for the Clearinghouse. Any attempt by the Clearinghouse to organize similar activities and surveys from scratch would merely compete with, confuse, and duplicate the efforts of this wide-ranging and extensive existing body of knowledge, rather than enhance it.

There are several reasons why it would be costly and difficult for the Clearinghouse to match, much less better, these information sources. First, as an upstart in an already crowded field, the Clearinghouse would lack the credibility to cultivate new contacts or establish relationships with information sources. Second, where strong networks already are in place, the Clearinghouse would have to supplant these existing relationships with a new, more tenuous,

relationship to Washington. And, finally, given the limited resources at its disposal versus the sheer variety of areas of expertise required, the Clearinghouse quickly would become bogged down in the enormity of the task.

## A Niche for the Clearinghouse

The problem is not a dearth information on state and local initiatives, but rather a lack of organization, availability, and easy access to the information that is being collected. An obvious niche for the Clearinghouse may be to function, not as a database, itself, but as a one stop referral service (a kind of Yellow Pages guide) to the vast information resources and networks that are already operating and proliferating.

This model offers several advantages. First of all, the information is not separated from its original source. This means that users can be led directly to the field and to the expertise associated with the topical area. Second, it offers the user relatively inexpensive access to a richer body of material than he might discover on his own. By the same token, this system leverages the limited resources of the Clearinghouse by enabling it to provide access to more material than it could have, had it merely served up a database of its own making. Third, and perhaps most importantly, it positions the Clearinghouse to identify gaps where information is not available or up to date, and to take steps to enhance weaker links in the overall system of networks.

Such a role for the Clearinghouse is also a politically neutral one. True to its mandate, the Clearinghouse will not seek to evaluate individual state and local initiatives. But the access provided by the Clearinghouse would enable state and local officials to lay out their own options, weigh the costs and benefits of alternative mechanisms for enhancing competitiveness, seek out the expertise of their own choosing, and evaluate their success or failure according to the standards they set for themselves.

Rather than imposing rigid, and potentially inappropriate, evaluation standards in the guise of federal "guidance", the Clearinghouse can function more as a "consumers' handbook". It can maintain a listing of evaluations carried out and provided by state and local agencies, put together a catalogue of the kinds of evaluation criteria that are presently in use, and help agency officials and businesses determine how appropriate certain initiatives are in meeting their needs.

**Some Operating Principles**

To operate as a central point of access for other directories and networks, the Clearinghouse must not only unearth their existence, but also establish a relationship with these entities and identify or create incentives for them to participate in the system. For some of these networks, the incentive may be the visibility that the Clearinghouse can provide their service and the additional business that will flow their way from the free advertising. In a few cases this may actually be a disincentive if the volume of requests becomes overwhelming and too costly to handle for the grass roots network or program administrator to whom Clearinghouse referrals would flow. Here, the network might start imposing a small fee to weed out less serious requests, or the Clearinghouse could assist in establishing an alternate point of contact.

Another incentive the Clearinghouse might offer is one-time financial help (subject to availability of funds) or technical assistance for some networks to update their material or to strengthen their capacity to handle inquiries. In this manner, the Clearinghouse also would work toward its goal of improving the recency and quality of data available to its users, and the timeliness with which it is delivered.

For some networks, advertising the Clearinghouse as a source of information that will be tapped by members of the U.S. Congress may be a powerful incentive to participate. It will give the networks a chance to showcase their programs and operations to policy makers.

Finally, the Clearinghouse can stress the need to cooperate sub-nationally and across industries in order for the U.S. to become more competitive internationally. Improving U.S. productivity and the standard of living of all Americans is, after all, the conceptual motivation behind the Clearinghouse, in the first place.

Besides creating incentives for participants in the network database, there must be incentives for the users of the Clearinghouse to seek access. What is needed is a system that is open through multiple doors or points of entry and that is intuitively easy to use. Though, one day, it may be desirable to make the system accessible through sophisticated communications technologies, those users with only a rotary phone or a nearby mailbox-- or even just anyone who needs help in framing a question or request-- should be able to reach a personable and knowledgeable individual on the receiving end.

Personalizing, widely advertising, and providing multiple contact points might best be achieved by decentralizing and developing "nodes" for the Clearinghouse outside of Washington in

each of the fifty states. One appropriate place for a user to lodge a request, for example, may be with state technology extension agents. Other sensible options, possibly including local economic development offices, should be enlisted, as well.

As part of the process of fostering and nurturing existing networks, Clearinghouse-sponsored conferences may be useful. Conferences would help strengthen the organized networks, organize the unorganized networks, revive the less active networks, and create new networks (e.g., organizations that promote the adoption of flexible automation equipment). They also would provide a forum for individuals to meet with one another and establish working relations, and to share "war" stories about the difficulties they encounter in creating initiatives and in evaluating their programs. As part of the conference agenda, the Clearinghouse could feature lesser known, but particularly valuable, directories and networks.

## Work Plan

By the end of FY89, the Department of Commerce and ACIR are committed to completing a basic design for the Clearinghouse and hope to have some portion of the Clearinghouse up and running. What this actually means, of course, is to a large measure determined by the ultimate design of the Clearinghouse. For the Clearinghouse as it is proposed here, this could be the identification of core networks, the choice of a technical system for linking them together, the shell of a database with at least a limited set of answers to the most frequently asked questions, and plans for a conference in the fall to unveil the system and foster network contacts.

Between now and then, there will be critics' sessions to obtain advice on key issues, an investigation into the organization and operation of other clearinghouses (dealing with other subjects, such as medicine or juvenile justice) to learn the lessons of similar efforts, and an identification of options for appropriate hardware and software to ensure that the Clearinghouse is a practical and accessible place for inquirers to turn.

## A Summation

Several factors--some seemingly conflicting-- constrain what the appropriate content and role for the Clearinghouse might be. First, the Clearinghouse has been charged with a broad mandate in the authorizing legislation, but it has been granted limited resources with which to achieve it. These resources amount to $250,000 for FY 1988 and FY 1989, respectively, with a similar amount anticipated to FY 1990. Second, while the Clearinghouse is expected to help develop methodologies to determine which initiatives lend themselves to replication, it is not permitted to

evaluate individual state or local initiatives unless specifically requested to do so by the state or locality. Finally, preliminary investigation has shown that there are a number of organizations--and just how many is not yet known-- that already serve segments of the business and public sector communities that are potential users of the Clearinghouse, and do so with varying levels of quality, cost, and recency of information.

These considerations suggest to ACIR and the Department of Commerce a design for the Clearinghouse that is based, in part, on the concept of the telephone Yellow Pages. Though more descriptive than a traditional telephone directory, it would serve a similar function as a guide to the vast information resources and networks that are already operating and available.

In addition, and in a more active capacity, the Clearinghouse could foster working relationships between organizations, encourage existing networks to maintain the quality and accessibility of their information, identify gaps where information is not available or recent, and promote cooperation among businesses, public officials and citizens so that they can determine how well the state and local initiatives are achieving the objectives they have set for themselves.

## Critical Issues for the Clearinghouse

- o Is this "yellow pages" conception a sensible first step for the Clearinghouse? How might it be improved? How might the Clearinghouse complement rather than compete with private sector sources of information and expertise?

- o Are the incentives discussed under "Some Operating Principles" sufficient for contributors of information to be willing to participate?

- o What would be the logical points of entry for taking advantage of Clearinghouse resources from within the States? What role would be most appropriate for technical extension agents?

- o How can the Clearinghouse be most helpful to users in addressing their evaluation needs?

- o What information should be centralized within the Clearinghouse and what information should be decentralized outside of it?

- o Should the Clearinghouse include information on private initiatives such as those of local power companies, large corporations, or private venture capital organizations?

- o What has been your prior experience with Clearinghouses, and what is best repeated/avoided?

- o What other groups, networks, and databases should be consulted and included, or developed anew?

Mr. KINCAID. Our next effort in designing the Clearinghouse will be to hold four meetings, what we call "thinkers sessions" on this issues paper. We have already consulted with a great many people. These formal sessions will allow us to evaluate our ideas through concentrated exchanges and criticisms from about 150 experts representing business, technology transfer agencies, public policy organizations, associations of state and local officials, federal agencies, academics and others.

These "thinkers sessions" are a normal part of our research process and we find them very useful in developing the projects that we work on.

I would add that near the end of the fiscal year when we have products, we will hold another round of meetings which we call "critics sessions."

Finally, as the Advisory Commission on Intergovernmental Relations, we will work very hard to involve the nation's state and local governments in the development of the Clearinghouse and in the utilization, maintenance and improvement of the Clearinghouse over the years.

The primary objective of the project, after all, is to make the initiatives of state and local governments more widely recognized and utilized across the land. To achieve that objective, we must have the enthusiastic cooperation of state and local officials. We are certainly enthusiastic about the project and we believe that it can play an important role in helping to promote American productivity and competitiveness.

Thank you for your attention. I'll be happy to answer any questions.

[The prepared statement of Mr. Kincaid follows:]

# A CLEARINGHOUSE OF PUBLIC SECTOR INITIATIVES TO MAKE AMERICAN BUSINESS MORE COMPETITIVE IN WORLD MARKETS

Testimony by
John Kincaid
Executive Director
U.S. Advisory Commission on Intergovernmental Relations

Before the
U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Science, Research, and Technology

March 8, 1989

Washington, DC

Thank you, Mr. Chairman, for inviting the Advisory Commission on Intergovernmental Relations (ACIR) to testify on its role in assisting the U.S. Department of Commerce to establish the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation called for by the Omnibus Trade and Competitiveness Act of 1988.

My name is John Kincaid. I am the executive director of the Commission. I have with me Dr. Bruce D. McDowell, acting director of government policy research for the Commission, and Ms. Barbara J. Lipman, our project director for the Clearinghouse.

Last summer, as the trade bill was nearing enactment, the U.S. Department of Commerce asked our Commission for assistance in designing and installing the initial Clearinghouse data base and dissemination mechanism in the Department. The ACIR is a most appropriate agency for undertaking this responsibility because the Commission has a nearly 30-year record of highly professional and respected work in policy research and technical assistance with a broad range of state and local governments and with the many national associations representing those governments, as well as with many federal agencies. The ACIR is an independent bipartisan commission established by the Congress in 1959. The 26 members of

the Commission constitute a broad cross section of American government--representing the U.S. Congress and Executive Branch, as well as state legislators, governors, mayors, elected county officials, and private citizens.

The Clearinghouse project comes at a particularly opportune time for the Commission because we are presently engaged in an examination of state and local roles in international affairs, with particular emphasis on the scope and effectiveness of trade and investment initiatives. The Commission was pleased, therefore, to respond affirmatively to the Department's request for assistance, and did so at its meeting on September 16, 1988.

The Commission believes that it possesses the unique qualifications required to provide this assistance in a manner that will ensure both the technical competence of the product and widespread acceptance of the Clearinghouse by the prospective users and information providers. By working closely with Commerce, we can develop a Clearinghouse that will be well suited to the needs and objectives of American business and the nation's state and local governments.

The organizing principle we have proposed for the Clearinghouse is based, in part, on the concept of the telephone Yellow Pages. We developed this concept because there are many public and private organizations that provide information and assistance to those involved in efforts to improve technology, productivity, and innovation. In fact, we are still in the process of identifying these information providers and their services. These providers include federal agencies, such as the Federal Labs Consortium, the Small Business Administration, and the Department of Commerce, as well as university-based technical information centers, state and local government organizations, public interest groups, and private sector trade and industry associations.

The "yellow pages" approach to compiling and describing information available from these entities is a very useful way to eliminate unnecessary duplication of services and to make efficient use of taxpayer dollars. This approach will allow the Clearinghouse to increase the visibility of existing sources of information, provide greater public access to existing resources, identify gaps where information is not readily available, and assist providers in filling those gaps. The Clearinghouse, therefore, will not compete with these information providers by attempting to reassemble the actual data already available or replicate existing surveys. Instead, the Clearinghouse will lead users directly to the source of the expertise and assistance they are seeking.

The "yellow pages" concept is consistent, as well, with the Congressional mandate for the Clearinghouse to enhance the value of the information available about "the nature, extent, and effects of" state and local initiatives. As noted earlier, because the Clearinghouse will be in a position to identify areas where current information is lacking, it also will be able to encourage other organizations to fill those gaps, and to improve the quality and recency of the data they collect. In addition, the Clearinghouse will be able to fulfill an important analytical role by compiling information on how state and local governments assess their programs, and an important service role by putting people attempting similar initiatives in touch with one another so that they can determine, for themselves, how well the innovations are working, or will work in their own situation.

Perhaps, therefore, one of the most productive and innovative contributions the Clearinghouse itself can make through the "yellow pages" concept is to build upon and reinforce those services already being provided by private businesses, professional associations, and federal, state, and local agencies. We believe

that developing the Clearinghouse along these lines will strongly encourage information providers not only to participate in the Clearinghouse but also to improve their own services.

I have attached to this testimony an issues paper that explains our current thinking about the Clearinghouse in more detail. I ask, Mr. Chairman, that this document be inserted in the record, and I invite the Committee's comments on it.

Our next step in designing the Clearinghouse will be to hold four meetings, or what we call "thinkers' sessions," on this issues paper. We have already consulted with a great many people, but these formal thinkers' sessions will allow us to evaluate our proposal through concentrated exchanges of ideas with, and criticisms from, about 150 experts representing business, technology transfer agencies, public policy organizations, associations of state and local officials, federal agencies, academics, and others. Such thinkers' sessions, which have been scheduled for March 22 and 29 and for April 4 and 6, are a normal part of the Commission's research process because we find them to be extremely useful. Depending on the outcome of these meetings, we may hold more thinkers' sessions. I should add that near the end of the fiscal year when we have products, we will hold another round of meetings, which we call "critics' sessions."

Finally, as the Advisory Commission on Intergovernmental Relations, we will work very hard to involve the nation's state and local governments in the development of the Clearinghouse and in the utilization, maintenance, and improvement of the Clearinghouse over the years. After all, the primary objective of the project is to make the initiatives of state and local governments more widely recognized and utilized across the land. To achieve that

objective, we must have the enthusiastic cooperation of state and local officials.

We are certainly enthusiastic about the project, and we believe that it can play an important role in improving the nation's economic productivity, boosting the ability of American business to compete more effectively in global markets, and enhancing the intergovernmental cooperation needed to help the federal, state, and local governments play their appropriate roles in promoting innovation and economic growth.

Thank you for your attention. I will be happy to answer any questions.

Mr. SKAGGS. Thank you very much.

Mr. Kincaid, I was a state legislator before changing jobs and used to get a lot of your publications, but never really understood where the Advisory Commission came from.

Can you flesh out a little bit your basis for existence and how you happened to get this job? That is, the job of overseeing the creation of the Clearinghouse?

Mr. KINCAID. The Commission was created in 1959 as the result of several congressional reports in the late 1950s on changes in the federal system.

We have a very broad mandate which, in essence, is to make the federal system work better. So, the Commission is an independent bipartisan agency which selects its own research projects and monitors trends in intergovernmental relations, and makes recommendations for policy improvements.

You're familiar with general revenue-sharing and block grants, for example. Both of those programs came significantly out of Commission work in the 1970s and 1980s. So, in addition to that, we have been requested by the Appropriations Committees of the Congress to at budget time raise additional revenues from the sale of publications from external contracts, and inter-agency agreements. Our work on the Clearinghouse is a result of an interagency agreement with the Department of Commerce.

The Department of Commerce solicited our participation in the program, requested that we provide assistance to them, and so we agreed to do so, primarily because it is a Clearinghouse on state and local initiatives, as well as federal initiatives.

And I think the feeling was that it was important to have an agency like the Commission that has long had an involvement in Federal, State, and local relations in cooperation.

Mr. SKAGGS. Mr. Coburn, did NGA object to that agreement being struck at the time, and do you object now?

Mr. COBURN. No. NGA did not, to the best of my knowledge, object to the agreement and I don't think we object so much now. We're just concerned that the goals are not being met as quickly and as promptly.

ACIR might be the ideal vehicle for that. It's just a question of direction.

Mr. SKAGGS. We've been joined by the distinguished gentle lady from Rhode Island, Ms. Schneider, who was largely responsible for the drafting of the provision that put it in the Trade Bill in this area.

Let me turn the questioning over to her.

Ms. SCHNEIDER. Thank you.

Mr. Kincaid, since Mr. Coburn is referring to a concern about the goals being implemented as rapidly as possible, could you articulate for me what some of the specific goals and time lines are that you do have in place?

Mr. KINCAID. Our agreement with the Department of Commerce was to provide a design of the Clearinghouse by the end of the fiscal year, an initial data base for the Clearinghouse, and a mechanism of dissemination and recommendations for how to make use of the Clearinghouse by the end of fiscal year 1989.

Ms. SCHNEIDER. So where are you right now?

Mr. KINCAID. We are—how many months into fiscal '89? We are very far along. We did not have a running start. You know, it started literally the 1st of October, our involvement in the project. I think that we have already identified the kinds of concerns that have been raised by NGA.

The immediate past chairman of NGA was a member of the Commission when the Commission entered into this agreement, and we are now at the stage where we have developed the basic concepts for the Clearinghouse for which we are now soliciting all the comments and thinker sessions that we'll be organizing in the next 2 weeks.

And then, pending the outcome of those thinker sessions, if there's a basic agreement on the general direction we are pursuing, then I think we can move ahead without any difficulty in meeting our goal.

Ms. SCHNEIDER. How frequently do you have your thinker sessions?

Mr. KINCAID. We have 27 very active projects at the Commission, and so we have thinkers sessions on all those projects, and critics sessions as well.

Ms. SCHNEIDER. But, on the Clearinghouse itself?

Mr. KINCAID. These will be the ones we are planning in the next two weeks. The first thinkers sessions we will have had on the Clearinghouse in that sense.

Ms. SCHNEIDER. But, there are 26 of them?

Mr. KINCAID. I'm sorry. I'm saying that the Commission as a whole has an agenda of 26 projects of which the Clearinghouse is one.

Ms. SCHNEIDER. So the Clearinghouse thinker sessions would be happening how frequently?

Mr. KINCAID. We have four planned at this point in time in the next couple of weeks; based on the attendance and participation and comments we get from those four, we'll assess whether we need to have additional thinker sessions. And then, as I mentioned earlier, at the end of the road when we had products then around what we call the critic sessions.

Ms. SCHNEIDER. Is there any chance of my receiving an invitation to any of those thinker sessions?

Mr. KINCAID. Absolutely. They are open.

Ms. SCHNEIDER. I do feel I have a vested interest. I'm giving birth to this project. I really am concerned that it meet up to not only all the thinkers on that panel's expectations, but my own expectations.

Mr. KINCAID. We would be happy as well to supply you with a list of all the people who are invited to all four sessions.

Ms. SCHNEIDER. That would be greatly appreciated.

Mr. KINCAID. We've worked very closely with the Commerce Department. Basically, we've cast a very large net in the last couple of months to kind of narrow this down and identify the key issues that we should be focusing on in this design process.

Ms. SCHNEIDER. Is Mr. Coburn a part of one of those thinker sessions?

Mr. COBURN. One of my staff is.

Ms. SCHNEIDER. Good. Who do you see as the users of the Clearinghouse?

Mr. KINCAID. We would see the users being state and local governments themselves. Certainly, the business sector, industry, university extension services and state programs involving universities and business incubators and things like that, as well as the service providers themselves; because what we hope we'll do is, by having this yellow pages operation building upon existing providers, we will encourage interchange among the providers themselves and, in the long run, help to improve the provision of information.

Ms. SCHNEIDER. It sounds good. In that process, do you feel that you're broadening or narrowing the purposes of the Clearinghouse?

Mr. KINCAID. I'd be reluctant to say at this point, until we have a little input from the thinker sessions, because there are different points of view on how we should approach this.

One of the issues that has to be determined in the design of the Clearinghouse is:

What is the scope of information included in it?

And you get some very broad definitions of that, so we have to look at what seems to make sense, what from the end point of the users they really seem to want and what the budgetary resources will be for the Clearinghouse.

Our understanding is that the funding projections are $250,000 a year. That's not a whole heck of a lot of money to tap what is actually going on out there.

Ms. SCHNEIDER. Ah, yes, but we know you're so very creative in stretching the dollar, we figured that was adequate.

Mr. KINCAID. We are actually. I think we'll end up presenting a range of scenarios as to what seems to be most feasible given various resources that could be devoted, and we don't intend to limit the design by fiscal constraints.

What we intend to lay out at the end of the process is:

Here's what looks like the best design. That may not be feasible, but here's what you come back up to. And then look to in the future when you build the Clearinghouse.

Ms. SCHNEIDER. Mr. Coburn, how do you see the purposes of the Clearinghouse being defined?

Mr. COBURN. Well, as you had discussed previous to the Trade Act and as is highlighted in the Committee report, we see them specifically relative to state and local programs.

I am troubled, as I indicated in the testimony, with the notion of businesses accessing a service directly in Washington. I think it undermines that concept, undermines the whole notion of the appropriate role of the state and local programs relative to the appropriate role of the Department of Commerce.

I can say, from running a program in Ohio that we have 700 companies actively involved, paying up to $60,000 a year to participate in those programs, that marketing to business, getting business involvement, is entirely different than getting public sector involvement. And, again, looking at an available budget for the foreseeable future of $250,000 a year.

It's hard to imagine how you're going to successfully market to both businesses and market to the public sector. It's a different set of services altogether. And I would argue that if the Commerce is going to build up these existing programs, they're the ones who should most appropriately interact with the businesses.

Ms. SCHNEIDER. Insofar as targeting the mission of the Clearinghouse, what would you propose?

Mr. COBURN. The way I see it, in terms of an overview or conceptual perspective, I think the State and local programs at $550 million a year fill a special niche in the magnitude of the public sector research enterprise, which is $70 billion a year.

But that special niche is a very important one in the same way the Clearinghouse that's built can fill, even at $250,000 a year, a very special niche.

But, if the mission is expanding and not tightly focused, it will never fill that niche. It will get lost. There are state programs, including our own, that spent $250,000 every 4 days that we're doing business. That's not a significant amount of money.

So, anyway, I think there's a niche here to be filled with clear guidance. And I think that if there has been clear guidance from the Congress, it can be filled very effectively.

Ms. SCHNEIDER. And how about how would you increase the participation on the part of state and local governments?

Mr. COBURN. In the testimony, I suggested that there should be consideration given to some kind of formal or semi-formal board advising the Department of Commerce in the operations of the Clearinghouse. There's a lot of different vehicles for that in the Federal Government.

But I think a proper one could be found. I think any time we lose sight of the initial reasons for the creation of the Clearinghouse, we risk any positive accomplishments.

Ms. SCHNEIDER. That, too, is my concern.

Do you feel that perhaps your active participation on the part of perhaps more State and local governments in those thinker sessions or the critic sessions would be useful?

I know, Mr. Kincaid, we could have an open discussion on this, and I would like to hear your feedback on that possibility.

Mr. COBURN. Unfortunately, we're testifying before those sessions have taken place. So, basically, we're reacting to the issue paper presented by ACIR and some discussions we've had throughout the Commerce Department, which is another issue.

And we're trying to give some feedback on the basis of some very preliminary actions. It may turn out that every one of these issues will be dealt with. And this isn't going to be a major set of problems.

But, at this time, I think there's cause for concern.

Ms. SCHNEIDER. My only concern is that you may be in a position of reacting. Since the program is essentially made for your purposes, wouldn't it be better to be part of that design forum?

And is that possible, Mr. Kincaid, in the structure you have conceived?

Mr. KINCAID. We have been in regular contact with NGA staff and the staff of other organizations on this. The big seven, quote/unquote, state and national associations are the principal constituency of the Commission and participate regularly in all of our research programs concerning the Clearinghouse through the thinker sessions, through the representation of all these officials on the Commission, including last year's chairman of NGA, who is a

member of the Commission and through thinkers sessions at the staff level, through the thinkers sessions and the critics sessions.

So, in addition, we go to the other State and local associations other than the umbrella ones which are appropriate for whatever particular project we are working on, so that we have a very open process in that respect.

I think the thinkers sessions will bear that out.

Mr. SKAGGS. If my colleague would yield on that, specifically what's your reaction to Mr. Coburn's suggestion of some kind of ongoing formal or informal advisory board that would presumably have some continuity beyond your thinker and critic kinds of sessions?

Mr. KINCAID. I think the Commission will take that recommendation into consideration in making its recommendations to the Department of Commerce.

Let me say that the Commission is not looking for some kind of continuing institutional role in this. Our forte really is to design ideas and get them into the policy arena in terms of intergovernmental relations and cooperation, and to limit the number of things that we do long-term on an institutional basis so that the final decision on that would have to be made by the Department of Commerce.

Mr. SKAGGS. Do you see a potential for spinning this entity off into some freestanding form?

Mr. KINCAID. Again, I wouldn't want to project on that at this point. I think our role is to kind of design and make recommendations to the Department of Commerce and they will pick up the ball after that.

Mr. SKAGGS. Thank you for yielding.

Ms. SCHNEIDER. So that means that perhaps what could happen is that Commerce could say, "Well, this is a terrific idea, this Clearinghouse, and we would like to incorporate it into our general programs."

Or, Commerce could say, "Look, this is a great idea the way you've designed it, but we think, the National Governors Association, ought to do it."

Is that what you're saying? There's those two alternatives?

Mr. KINCAID. There are probably more alternatives than that that I think what the Commission will do is produce a set of recommendations. That's what we're being asked to do on how that should be set out. And one of the reasons for coming to the Commission is to be sure that all the relevant state and local government interests are represented in the Clearinghouse.

Ms. SCHNEIDER. One of my concerns is that we not lose time because as we lose time, we lose money. And seeing as how this is such a small amount of money, I think that we should not get into the conceptualization of the design mode on the one hand and then we have to go to the reactive mode. And they say, no, no, go back to the drawing board, this doesn't quite fit our needs.

And then we decide, well, the whole program was a waste. I mean, I really feel that we all have the same goals. We are all in this together. So the more that we can work in a united way, I think the more successful we can be assured of achieving those goals.

Mr. KINCAID. The initial reactions that we have received on our issues paper have been by and large quite favorable. And we're not aware of any major problems in that respect. But we won't know for sure until we go through these four thinker sessions and we really sit down around the table. And that's why we have those sessions, to bring together the relevant people to discuss those issues.

And we think the design issue is very closely connected with the intergovernmental cooperation question.

Ms. SCHNEIDER. Mr. Coburn, give me an idea of what you from your humble viewpoint could be improved upon right now?

Mr. COBURN. I think ACIR has a tough job in the sense that there are a number of different organizations that have to be brought in, and the level of awareness in the federal agencies varies tremendously.

So there's an education process as well as a soliciting of people's opinions. At this time, they seem to be very forthright about getting people's input. The concern is just that if someone has to memorize these two pages of the committee report on the Trade Act to remind themselves that it's a state and local program that motivated the creation of the clearinghouse and they should be the end beneficiaries as well as the public sector research, enterprises in total, then that should be done.

I can say, having been involved in this since the middle of '84, it's been a slow process of education of the different Federal agencies and it's important that the Congress for the agencies that haven't achieved a certain level of sensitivity helped them to achieve that.

Some agencies, like NSF, NIST, have been very progressive about recognizing what the states can mean. Other agencies, I think indifference is being charitable in terms of their willingness to recognize the states. The states want to be partners. The governors of the states have expressed themselves very clearly on this.

So, I think I wouldn't recommend any specific changes, but I think the overall points in the testimony, the formal or informal board, the recognition that private sector business constituents are not the target for the Clearinghouse, those kind of recommendations I think should be acknowledged as soon as possible and should be put in front of the board.

Ms. SCHNEIDER. Granted we have in the legislation, you know, fiscal year, but I must share with you that the urgency to get some of the information out is awesome.

Things that immediately come to mind is information about our energy efficiency technology. Our Science and Technology Committee has been developing products. Now they are commercialized and we need to have these things out there in the state and local governments.

And businesses, too, can be involved in maximizing some of the export potential there. And understanding that there is a market there.

And the same thing with other things this Committee has dealt with, like generating information on reuse, recycling of hazardous wastes. The State and local governments are going nuts trying to figure out what do we do with this municipal landfill now that we've found out that it contains hazardous materials.

We have the answers. And the problem is I've been sitting on this Committee for 8 years now and I'm wondering why aren't these local governments getting the answers more quickly.

So, Mr. Kincaid, I can't impress upon you enough the urgency. It would be great if you could disregard the deadline that we have set in terms of accomplishing those goals a little earlier, because I think speed is of the essence here.

Mr. KINCAID. We will make every effort to do that.

Ms. SCHNEIDER. I'll look forward to participating and learning more about your thinker sessions, if I can help stoke that fire along.

Thank you.

Mr. SKAGGS. Thank you. Let me offer one bit of advice also to Mr. Coburn.

I at least noticed that your remarks talk about NGA and occasionally the League of Cities and NCSL was notably absent. I hope, as a former State legislator, you are making common cause with your co-equal branch representatives there.

Mr. COBURN. Mr. Chairman, my budget is in the Ohio House this week. [Laughter.]

Let me say that we don't have to take a test on the importance of that.

Mr. SKAGGS. Very well. We thank you both for joining us.

Now, this afternoon, I believe that concludes our agenda today. This hearing will be adjourned.

Thank you.

[Whereupon, at 1:05 p.m., the hearing was adjourned, to be reconvened subject to the call of the chair.]

# DEPARTMENT OF COMMERCE TECHNOLOGY PROGRAMS

THURSDAY, MARCH 23, 1989

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
*Washington, DC.*

The subcommittee met, at 9:40 a.m., in room 2318, Rayburn House Office Building, Hon. Doug Walgren (chairman of the subcommittee) presiding.

Present: Representatives Walgren, Boehlert, Brown, Morella, and Ritter.

Mr. WALGREN. Well, let me bring us to order and begin.

Today is the third day of this subcommittee's hearings on the Fiscal Year 1989 budget of the National Institute of Standards and Technology.

I know that everyone who comes to these hearings understands that standards and the work that the NIST is designed to accomplish is extremely important in the ability of the United States to compete in world markets, and the ability of our companies to manufacture precisely and to develop and manufacture goods of quality really depends on the quality of our measurement and the availability of standards and measuring capabilities that are developed at the NIST on a broad-based level. At the same time, the initiatives that are taken in new measuring technology are the first crack in the door for new capabilities in technology.

So, the work that is done at the NIST is really the start of so much of the potential of our economy to innovate and to develop competitive products that would be able to do well in the world market.

And yet somehow or other, at least in the number of years that I have been aware of these budgets, they have not had the support in any real way from any Administration since 1980. And this year, I am afraid, is no exception.

Essentially, the standards function of the bureau over the years has been held quite flat, without growth and really being asked to absorb the year-to-year increases in cost that are inherent in any effort of the Federal Government. Age increases and have essentially eroded over time because of the impact of inflation.

This year, the Administration proposes $15 million in new initiatives, but the problem is that their total budget for the NIST is $3 million less than it was last year. Now, when you factor in inflation on top of that and ask yourself how much of a reduction you

would have to take if you were to provide that $15 million for new initiatives and yet live within that overall ceiling, that is, I think, the definition of no support for the basic functions of the NIST.

They again propose to take a significant part of that $15 million out of things that the Congress has rejected, and those are reductions in the fire and the building programs. The Congress has stood with those programs because they are basic public safety functions that any industrial country should pursue. And yet, again, we see major reductions being asked in that area.

They also unfund the work in chlorofluorocarbons, one of the real targets of efforts to have long-range environmental protection and sensitivity to what industrial society is doing to the environment.

And then there is just nothing provided in response to the trade bill last year, no funding for the Hollings generic manufacturing centers that we have great hope for and that have achieved a very wide consensus as to their importance in our country.

No funding for the advanced technology function of NIST, even though we spent all day yesterday hearing how our failure to look forward in technology and try to be a catalyst in certain areas is threatening in high-definition television to leave us just out in the cold of a major generation of industrial technology that will determine Nations' strengths for certainly several decades before another major advance in those areas comes along. But yet, from this Administration, no pickup, no nothing for the advanced technology function that we anticipated for the NIST.

So, it is clearly again a situation where the Congress is going to have to be the mainstay of the national interest. Maybe that is not all that unusual, although you wish that Administrations would at least help pull in the right direction. That does not apparently seem to be the case, and the Congress will just simply have to fill in the vacuum that they leave.

Well, with that, I would like to recognize the majority—the ranking member of the minority.

Mr. BOEHLERT. Someday, Mr. Chairman, someday. [Laughter.]

I just would like to comment initially, after listening attentively to your opening statement, that while the Administration doesn't always do everything we want, they sometimes do. We don't have quite as good a record with the Appropriations Committee, so we have got some work to do, Mr. Chairman, with that committee, as you well recognize.

This is our third hearing this month on the National Institute of Standards and Technology. So, I just want to comment briefly on a perennial concern that will be addressed today. I am referring, of course, to the center for Fire Research and the Center for Building Technology.

The budget proposal for these centers reminds me of those trick birthday candles that parents buy for their kids, you know, the kind that kids think they've blown out but somehow they manage to reignite.

No matter how many times the Congress extinguishes this pointless proposal, the wizards at OMB make it reappear. This juvenile gimmick has left us winded and exhausted with irritation, not with

delight. I hope this will be the last year we have to engage in this wholly predictable debate.

The two centers engage in significant research which promotes both the safety of the public and the competitive stance of American industry.

I continue to be mystified by OMB's contention that these programs are somehow fundamentally different in their nature and purpose from the Institute's other programs. I pledge once again to keep these two programs alive.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Boehlert.

Are there other comments that members would like to make?

Mr. Brown?

Mr. BROWN. Mr. Chairman, I want to commend both you and Mr. Boehlert for the obvious wisdom of your statements and pledge myself to support the same efforts that you obviously want to make.

I too have been through this for quite a few years, and I do not expect to see anything different develop out of this year's hearings and this year's confrontation than in the past. We will make marginal efforts to improve these programs or to maintain them.

It will be a struggle. We will have to fight with the Appropriations Committee for adequate funding. That fight, of course, is made much more difficult because they perceive that they have the support of the Administration in cutting into these programs, and obviously they have to save money in any way that they can. And I am, frankly, sick and tired of it.

I would almost be willing to say right now that we ought to double the budget of NIST and specify where we want that money to go, including the programs for advanced technology and maintaining the institutes and doing some of the other things that need to be done and that we go out and fight for it.

I think we will get great support this year in the Senate. Mr. Hollings would like to see the Centers for Manufacturing Automation funded. I think he would support the Advanced Technology funding that we need so badly, and certainly we would get support in preserving the Institute.

I think we ought to throw down the gauntlet and prepare to gird our loins and do battle on this thing.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mr. Brown.

We just will talk about that and see what kind of support we might expect for that kind of approach, and I think that there does come a time where that is really the right response.

Well, our first witness today is Congressman Curt Weldon from Pennsylvania.

Is Curt still with us? Okay.

I would just like to say, without any hyperbole or any exaggeration whatsoever, Congressman Weldon has just made so much progress in an area, among others but particularly his interest in fire since coming to the Congress. He has been the organizer of the Congressional Fire Caucus, which now got the attention and the active membership of almost all the Members of Congress, because all of us have that problem in our district, and it apparently was

just waiting for somebody like Curt who was personally deeply involved in volunteer fire efforts on a local community level to understand what a sleeping giant there was there and how to awaken it.

So, I in the 12 years that I have been in the Congress have never seen one individual come to the Congress and be able to cause so much interest and so much activity and focus in one area, and particularly an area that involves lives, because we lose 6,000 people a year, and we are going to lose less because of the direction that Curt has brought to this area.

So, we are all very grateful and very admiring of what you have done here, Curt. So, welcome to our committee, and we are pleased you are here and participating in our proceedings.

## STATEMENT OF HON. CURT WELDON, U.S. REPRESENTATIVE FROM THE STATE OF PENNSYLVANIA

Mr. WELDON. Thank you, Mr. Chairman. And let me say it is an honor for me to be here. I thank you for those kind comments.

I am here, as you know, to testify in support of the Center for Fire Research. But perhaps more importantly let me commend you personally and Mr. Boehlert and the entire committee, including Mr. Brown and my other colleagues that serve on this Subcommittee, for their untiring support in the past when we have had an Administration that is of the same party that I am that has not been sympathetic and understanding of these concerns.

We are trying to change that, and I would be the first to admit that were it not for this Subcommittee and the personal leadership of yourself and Mr. Boehlert, we would not be here today because there probably would be no Center for Fire Research and there probably would be no Fire Administration, because if the Administration had its way in the view of OMB's proposals in the past eight years, many of these programs would have been wiped out. And that would have been a real tragedy for the American public and would have certainly caused a substantial increase in loss of lives and property in America.

I come before you today for the first time testifying on this subject, but in several different capacities. First of all, you alluded to the Caucus for Fire Safety and Emergency Services. And as you know, because of your leadership we have become in one short year the third largest caucus of 98 on Capitol Hill. We currently number 310 Members of Congress among our ranks, and by our first dinner on April 12, my prediction is it will be the largest caucus on Capitol Hill. We will surpass the National Security Caucus, the Energy and Environment Caucus.

There is a real story there because it shows the broad-base support that the issue of fire and life safety has not just across America but also in Washington when we appropriately rally the support of our colleagues and identify the concerns that the fire service leaders in America have. This once again has happened largely because of a few stalwart men and women in this body and in the other body that have allowed those fire service leaders to have ongoing support in the past when it did not come from the Administration.

As you have done in this Subcommittee with so many different areas of technology, not just in the area of fire safety but across the board, allowing America to maintain its competitive edge and the beyond the cutting edge of new technologies, you have done the same thing in the area of fire research.

By supporting the levels of funding that you have supported in the past for the Center for Fire Research, we have solved many problems regarding building materials, ways to evaluate our buildings from the standpoint of fire spread, flame spread, protective clothing for children in the form of sleepwear and mattress flammability standards. All were developed through this vital organization.

And I am not just being here as a Member of Congress and Chairman of the Fire Safety and Fire Services and Emergency Services Caucus, but my previous background, I spent ten years for the I&A Signa Corporation, one of the largest property casualty insurers in the world. And at Signa I was responsible nationally for all of their programs that developed the training programs for their technical professionals, fire protection engineers, arson investigators, workers compensation specialists, 800 of these people nationwide; as well as responsible for the technical standards that we enforced as a large property casualty insurer, to reduce the potential of fire loss among our insurers.

In that capacity I had the opportunity to serve on several NFPA committees as well as several technical committees within the insurance community. And during that tenure, the ten years that I served with Signa directly involved with fire safety and looking at the technology problems that we have as a Nation, the Center for Fire Research has always been a vital component of providing industry with state-of-the-art technology and state-of-the-art experience as to where we should be going.

And to lose that would be an absolute blow to the industry in America who are looking for leadership on these issues that has been provided in the past by this organization.

As a matter of fact, it was approximately, I guess, 10 to 12 years ago that I took a trip out to the laboratories and had a chance to see firsthand the type of work that is being done there, long before I got involved in Congress and long before I got involved in politics.

And as someone who has been involved technically, who has a degree in fire protection, and as someone who understands the importance of continuing to look at new technologies, I can tell you as vehemently as I can say it that there is no way that we can allow an Administration, any Administration, to propose a 50 percent cut in funding for a program this vital.

I will use every ounce of energy that I have to support you and your leadership in restoring the cuts that have been proposed by the Reagan budget and, perhaps more importantly, in sensitizing the Bush Administration that this is just unacceptable, that we cannot allow this to happen.

While the cuts have been proposed, what bothers me the most is that they are also proposing to move and merge the Center for Fire Research with the Center for Building Technology, a further erosion of the identity of this fine institution and this fine group of

technicians who were there serving America with the technology necessary to meet the fire problem head on.

This is an absolutely, to me, unacceptable proposal, and I think we have to collectively fight that in a very aggressive manner.

Let me say that I am somewhat optimistic that perhaps over the next four years we will see a little better response coming from the White House and perhaps from OMB than we have seen during the past eight years. We lobbied hard with both major presidential candidates during the last campaign to sensitize them to issues involving the fire service in America, and we received responses from both groups.

The Bush campaign responded very aggressively and positively towards the fire service, and is now starting to turn those pledges and those promises into real commitments. Just last week I received word from the President that he will be our keynote speaker at our first national fire services dinner in Washington on April 12, where incidentally we will be honoring both of you for your past leadership.

The President not only said that he wants to be at that dinner, but he told two of his key staff people that he wants to get personally involved in fire safety and life safety issues. He wants to work with the fire service and to help those Members of Congress who have been out there when the Administration was not responsive.

That is a clear signal of change, and we have to take advantage of that. Now, I am not saying that things are going to change so dramatically that we won't have the fights that perhaps we will always have, but I think it will be much easier to get the response from the Administration than perhaps seeing the no response that we got during the eight Reagan years.

So, I would hope that you would continue your leadership, continue your pressure. I will guarantee that I as one person and one individual, very active in this effort, will continue to pledge my support within the caucus for this broad-based initiative that has the support of the entire fire service community. The joint council and all the major groups that make up the fire service in America are totally behind the center for fire research and continued funding—if anything, increased funding.

To go along with these cuts would just be, in my opinion, immoral because of the impact it would have on the lives of American people and children and our ability to keep up our efforts to reduce the threat to property and loss of life.

Let me say to you that another aspect that I bring to this debate is serving on the Armed Services Committee. I have just changed subcommittee assignments and am a new member of the Research and Development Subcommittee. And part of my effort for joining that Subcommittee is because we are spending not $2 million or $5 million on fire protection and fire research on the Armed Service side, we are spending hundreds of millions of dollars, none of which is coordinated.

I have never seen attempted cuts of this magnitude in any part of the military budget, especially as it relates to fire research or fire suppression or fire protection. And to me, it is unconscionable that the Administration would propose a 50 percent cut for this vital program.

If anything, we should be steering more funds to this initiative and should be trying to coordinate some of the existing defense funding for research into the center for fire research, which is an initiative that I will be taking up as a member of the R&D Subcommittee of the Armed Services Committee.

So, in the strongest possible terms that I can give to you, I pledge my full support and the support of the fire services caucus. And I would say to you that you have the backing of, I would say, the bulk of those 310 Members who have joined with us who are going to stand up and shout loud and clear to the Administration that this is just totally unacceptable.

I would hope that you would continue to be as aggressive as you have been, along with my colleague, Mr. Boehlert. And let me say that I can tell you that the fire service community appreciates what you have been doing. All across America, as I have traveled around this past year speaking to groups, national groups, State groups and local groups, your names are like gold to them because of leadership that you have provided in the past and the sensitivity that you have toward the issue of reducing the threat of loss of life and property.

So, with that, I would ask, if you would, to allow my statement to be put in the record. As you know, I have just kind of wandered along here this morning, giving you a very personal statement about how strongly I feel about this issue and to pledge my total support for your effort.

Mr. WALGREN. Well, without objection, your full statement will be included in the record.

[The prepared statement of Mr. Weldon follows:]

House Subcommittee on
Science, Research & Technology
March 23, 1989 hearing
Testimony of U.S. Rep. Curt Weldon

MR. CHAIRMAN, MR. RANKING MEMBER, MEMBERS OF THE SUBCOMMITTEE, THANK YOU FOR THIS OPPORTUNITY TO TESTIFY IN SUPPORT OF THE CENTER FOR FIRE RESEARCH.

I COMMEND YOU, MR. CHAIRMAN FOR YOUR ONGOING COMMITMENT TO FIRE AND LIFE SAFETY ISSUES AND ONCE AGAIN OFFER MY SUPPORT TO YOU AND TO THIS SUBCOMMITTEE IN THIS AREA.

AS CHAIRMAN OF THE CONGRESSIONAL FIRE SERVICES CAUCUS, I HAVE APPEARED BEFORE THIS SUBCOMMITTEE ON SEVERAL OCCASSIONS IN SUPPORT OF THE U.S. FIRE ADMINISTRATION AND NATIONAL FIRE ACADEMY PROGRAMS -- TODAY, THE ISSUE OF FUNDING FOR THE CENTER FOR FIRE RESEARCH IS MY REASON FOR BEING HERE.

AS YOU ARE WELL AWARE MR. CHAIRMAN, THE FY-90 BUDGET SUBMISSION FROM THE PAST ADMINISTRATION PROPOSES TO REDUCE FUNDING FOR THE CENTER FOR FIRE RESEARCH BY 50%. IF THAT WAS NOT BAD ENOUGH, THIS BUDGET SUBMISSION RECOMMENDS THAT WE MERGE THE CENTER FOR FIRE RESEARCH WITH THE CENTER FOR BUILDING TECHNOLOGY. IF WE ALLOW THIS TO HAPPEN WE MIGHT AS WELL TELL OUR NATION'S FIRE SERVICE THAT THEY ARE ON THEIR OWN AND THAT FIRE IS A LOCAL PROBLEM. IF WE DO NOT PRESERVE THE IDENTITY OF THE CENTER FOR FIRE RESEARCH AS WELL AS THE NATIONAL FIRE ACADEMY AND THE U.S. FIRE ADMINISTRATION WE ARE

CONCEDING THE 6000 LIVES AND OVER $10 BILLION IN PROPERTY LOST ANNUALLY AS A RESULT OF FIRE.

FRANKLY, MR. CHAIRMAN, THE ISSUE OF FUNDING FOR THE FEDERAL FIRE PROGRAMS HAS BEEN AN EMBARRASSMENT TO THIS MEMBER AND TO MANY OTHER MEMBERS WHO HAVE FOUGHT TO RESTORE THOSE FUNDING LEVELS OVER THE YEARS. WITHOUT YOUR LEADERSHIP, MR. CHAIRMAN, AND THIS SUBCOMMITTEE'S PAST SUPPORT, THE FIRE PROGRAMS WOULD HAVE BEEN ELIMINATED MANY YEARS AGO.

IN FY-81 THE CENTER FOR FIRE RESEARCH HAD A BUDGET OF $5.7 MILLION, IN FY-85 CENTER FOR FIRE RESEARCH WAS FUNDED AT $6.1 MILLION, AND TODAY WE DEBATE WHETHER OR NOT TO FUND THE CENTER FOR FIRE RESEARCH AT $2.7 MILLION. AS I HAVE STATED IN THE PAST, MR. CHAIRMAN, WE ARE DOING SOMETHING VERY WRONG. OUR NATION LEADS THE WORLD IN MANY AREAS, ONE OF THE MOST INFAMOUS BEING THE LOSS OF LIFE AND PROPERTY TO FIRE, YET, WE CONTINUALLY ATTACK AND SLASH THE MODEST FUNDING LEVELS AUTHORIZED FOR THE FEDERAL FIRE PROGRAMS.

MR. CHAIRMAN -- THE CENTER FOR FIRE RESEARCH PROVIDES OUR NATION'S 1.2 MILLION FIRE AND EMERGENCY SERVICE PERSONNEL WITH THE RESEARCH AND TECHNOLOGY ADVANCEMENTS NEEDED TO PROTECT OUR CITIZENS FROM THE RAVAGES OF FIRE. THE CENTER FOR FIRE RESEARCH, ALONG WITH THE U.S. FIRE ADMINISTRATION AND NATIONAL FIRE ACADEMY, COMPRISE THE FEDERAL FIRE TRIANGLE. EACH POINT OF THE TRIANGLE IS CRITICALLY IMPORTANT TO THE MISSION OF A FIRE SAFE AMERICA. CONSIDERING THE RELATIVELY SMALL AMOUNTS OF MONEY CONGRESS AUTHORIZES EACH YEAR FOR THE TOTAL FEDERAL FIRE COMMITMENT, I BELIEVE THE PROPOSED OMB REDUCTIONS ARE UNCONSCIONABLE.

I URGE THIS SUBCOMMITTEE TO RESTORE THE FUNDS TARGETED FOR CUTS BY OMB AND TO FULLY FUND THE CENTER FOR FIRE RESEARCH PROGRAMS. I CAN NOT STRESS THE IMPORTANCE OF THE CENTER FOR FIRE RESEARCH AS A CRITICAL BRANCH OF OUR FEDERAL FOCUS ON FIRE AND LIFE SAFETY. I AM CERTAIN THIS SUBCOMMITTEE WILL SEE THE WISDOM IN RESTORING THESE FUNDS AND SUMMARILY REJECT THE IDEA OF MERGING THE CENTER FOR FIRE RESEARCH WITH THE CENTER FOR BUILDING TECHNOLOGY.

ONCE AGAIN, THANK YOU, MR. CHAIRMAN, FOR THIS OPPORTUNITY AND I WOULD BE PLEASED TO ANSWER ANY QUESTIONS YOU OR THE DISTINGUISHED MEMBERS OF THE SUBCOMMITTEE MIGHT HAVE.

Mr. WALGREN. Curt, we want to express our appreciation to you for both what you have said here and also what you have done. You may really be in the key position because, as you know, when we look at particularly research monies, so much of it comes under the military umbrella.

Yesterday in the high-definition television area we were talking about the DARPA—Defense Advanced Research Projects Agency——

Mr. WELDON. You've got it. [Laughter.]

Mr. WALGREN. And their contribution of $30 million, just like that, to that effort. And they have the money. And it may very well be that the right strategy would be to spend the military money that is available in this area properly through the mechanism of the Center for Fire Research and build it that way.

I can't help but always remember those numbers in the presidential commission report on "America Burning," where in 1974 they essentially called for about $134 million a year in expenditure. These days that would probably be around $300 million after accounting for inflation over the last 15 years. And here we are at less than—well, with hardly anything—in the overall less than $15 million and in fire research in particular, you know, not even a third of that.

So, you can see how we essentially are making no effort compared to what was called for on a bipartisan consensus basis in 1974.

And maybe we can access and redirect or direct through the focus of the Center for Fire Research some of those monies that are being spent on research by the military.

Mr. WELDON. Mr. Chairman, I would offer to you as a member of the R&D Subcommittee an ongoing working relationship with your Subcommittee for an initiative, not just in the fire safety area but any initiative that you feel that we can assist from a defense standpoint.

You mentioned the total dollar allocation for the fire problem in America today in its broadest possible context. It is about $15 million to $16 million a year, as you mentioned, and we have been struggling just to keep that in the budget each year.

What is amazing to me, as I have begun this process of looking at the entire Federal spending initiative on all programs—and we haven't even gotten a handle on this yet—that we think there is well in excess of $1 billion a year being spent by the combined efforts of GSA, NASA, the various departments of the Defense Department, the Department of the Interior, on a multitude of programs that cover the broad spectrum from fire research to fire protection to fire suppression. None of that is coordinated.

Here we have the Center for Fire Research. By its name and by its title it should be the focal point for all of these initiatives and activities. Yet, none of that today is even totally comprehended by any one person. I am having trouble within DoD just getting a handle on the total dollars and programs that are currently being supported financially on this broad issue.

They don't even know where all this funding is going. And that is one of the goals that I have and one of the initiatives that we are going to be working on with the congressional fire services insti-

tute. As it is formed, one of its first priorities is to identify all of the existing funds, Federal funds, that are being utilized.

But you are absolutely correct, this should be the focal point and this should, if anything, be the clearinghouse for those initiatives. So, at a minimum, we have to continue the funding that has been there in the past and then pledge ourselves to identify more programs that could be coordinated through this agency as opposed to further watering it down and putting it basically into oblivion.

Mr. BROWN. Would the gentleman yield to me briefly?

Mr. WALGREN. The gentleman from California?

Mr. BROWN. I know we have a roll call on, but I can't resist the opportunity to commend the gentleman for what he is doing. I think this is marvelous. I would want to warn him of the frustration he is likely to encounter in trying to bring order into multidepartmental programs. It is a very frustrating task.

But let me suggest to you a focus that might be extremely helpful, and that is to look particularly at our civil defense operation, which has a small—but compared to this, substantial—budget of over $100 million, I think.

Mr. WELDON. $160 million.

Mr. BROWN. And which has as its responsibility the management of critical problems related to, of course, a war situation, but we are in a war here. We are trying to improve our ability to respond to crises with this kind of thing. And the civil defense organization has been charged with that responsibility for war, for earthquakes, which it doesn't do very well, and for a number of other programs which all ought to be brought together in a multihazard planning and research capability which would benefit their main mission and which they don't seem to see the value of.

Mr. WELDON. Your comments are absolutely correct, and I can tell you that one of the battles that I have been fighting over on the Armed Services Committee as a member of the Military Construction Subcommittee that oversees the FEMA budget, has been FEMA's total lack of appreciation of the fire services' role in that agency.

You have seen this as well. I mean, were it not for this subcommittee, FEMA would have basically also continued the erosion of the National Fire Academy and the U.S. Fire Administration. So, once again your subcommittee has been a savior in that regard as well.

Mr. WALGREN. The gentleman from New York, Mr. Boehlert?

Mr. BOEHLERT. We have to leave shortly for a vote, but I just want to commend you, Congressman Weldon. You have been an outstanding leader in getting this Fire Services Caucus off the ground, and not only off the ground but to rapidly becoming number one of all caucuses on the Hill.

Now, there is bad news and good news. The bad news is that with the steady, but uninspired, hand of OMB the past Administration recommended all these cuts in the fire programs.

The good news is that it was the past Administration. And as the President says—and I don't want to be accused of being partisan—but there is a new breeze blowing in this town. A comforting thought to me.

I was in the snowy hills of New Hampshire campaigning for then-candidate Bush, and it was about 10:30 at night, and where do you go to campaign at 10:30 at night? You know where to go and I know where to go. I went to the central fire station, and I was giving the big pitch for George Bush, and to my surprise they said, "Hey, don't worry about George. We know him well. He stops in now and then and talks to us."

You have worked very well with him, as I have. He is going to be very supportive of this. This subcommittee, this full committee, this House, this Congress will not permit the decimation of all these vital fire services programs. And that is partially a tribute to your outstanding effort. Thank you.

Mr. WELDON. Thank you. And I think he knows that well, Sherry. He knows we will take him to the wall if he does. [Laughter.]

Mr. WALGREN. Thank you very much, Congressman Weldon.

Let's suspend for ten minutes in response to this roll call, and then we will get to the witnesses that have come from the private sector.

[Recess.]

Mr. WALGREN. Well, let me call us to order and assemble the first panel.

Ralph Richardson, Fred Ling, and George Rice, Russell Drew, and Gary Davidson, if you all would come forward.

As you know, gentlemen, our practice here is to reproduce the written statements that you might want to submit for the record, and they will be incorporated in the record and available for those who use that instrument. And you can feel free to focus on points or portions of the written statements if you want to underscore or emphasize the points you would like to make.

Let's go through the panel in the order in which I called you forward. So, we will start with Mr. Ralph Richardson, who is the president and publisher of Managing Automation, which is a publication out of New York.

So, let's start with you, Mr. Richardson, and then we will turn to Mr. Ling and Dr. Drew and Mr. Rice and Mr. Davidson in order.

## STATEMENT OF RALPH E. RICHARDSON, PRESIDENT, MANAGING AUTOMATION, THOMAS PUBLICATIONS

Mr. RICHARDSON. Thank you, Mr. Chairman.

I am appearing today as the representative of an informally organized group of automation equipment and software producers and of trade association officers. And I thank you for giving me this opportunity to put before you a plan that we have developed for helping small and midsize manufacturing companies to become more competitive.

Before I describe the plan and the steps we are taking to try to turn it into a functioning program, I should first say that my written testimony describes the nature and the extent of the problem in some depth.

By way of a precis of that testimony, I would like simply to say that as with every other industrialized nation, we enjoy an independent network of small and large manufacturing enterprises,

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every segment of which is essential to the whole. That in our new, fiercely competitive global economy it is essential that all manufacturers adopt some degree of the new advanced manufacturing technologies and their attendant improved organizational processes and management methods, that the very largest American manufacturers have so adopted these technologies, but that because of particular conditions which are described in the written testimony, our small and midsize manufacturing companies have largely failed to adopt these technologies and are, therefore, clearly falling behind their foreign counterparts in their ability to compete here as well as overseas.

Now, it seems to us ironic that while we as a society have poured unmeasured wealth into technology development, we have failed to take reasonable steps to employ these technologies for our own benefit.

As you well know, the rest of the industrial world has not so failed to use our technology developments. Every country in Europe and every industrialized nation in the Orient has programs of direct help for small manufacturers. And most of these programs are also outlined in my written testimony.

So, what then is to be done about our failure in technology transfer? Our group has developed a plan which we believe is in keeping with the American way of doing things. It is a private sector initiative which ties existing activities into a communications network aimed at bringing realistic help to these small companies on an as-needed basis.

It is a plan which will connect existing private sector, State, academic, and local activities to each other and, in turn, to those Federal Government activities which pertain to this problem.

The plan is based on the conviction that the best hope for a solution is appearing at the local level, often with State assistance, in the form of technology transfer centers. Their function is to reach out to the small- and mid-sized companies in their areas to help them adopt existing, off-the-shelf automation technologies. This help most often extends to planning and training both management and worker, as well as to equipment assistance.

Now, I should make special effort here to emphasize that our plan is referring to those local technology transfer activity centers which are aimed at helping small companies become more competitive through training and through the adoption of off-the-shelf technologies. We are not talking about the several other types of technology development and transfers such as advanced simulation or vision technology development or of finding ways to move leading-edge technologies out of the laboratories into commercial development or application. Those are critical jobs to be done, but they are not the need that we are addressing.

Our centers, the centers we are talking about, are, for the most part, setting up advanced production facilities for both hands-on demonstration purposes as well as for training purposes. They often need help in designing these facilities and in obtaining specific equipment from vendors. They also need help in designing and implementing training programs and in providing automation planning consultation.

It is the intent of our plan to help all these local centers perform their functions. And the triangle graphic that I have attached to my opening remarks and is on that chart over there can best portray how we see this network plan working.

Very simply, obviously the small and medium-size companies at the bottom of the chart are the intended people to be helped. The key element of this triangle, as I mentioned—in the lower right corner—are the local technology centers. And by this we mean the local technology centers that are being State-funded, are being locally funded, they are being funded by private enterprise. They in many cases are community colleges. There is a great variety of types of local technology transfer centers attempting to help the small companies.

As I mentioned before, their biggest problem—one of their biggest problems—is to make contact with the equipment vendors, the hardware vendors, the software vendors, the consulting people, who can help them set up their operation and to help them continue to run their operation.

To bring these two totally separate worlds together, our notion is to create a liaison office—which is at the top of the triangle—whose purpose would be to serve as a window between the local technology centers and the automation equipment, et cetera, vendors.

Now, for this plan to work, we have introduced the notion of trade associations and State and regional offices as elements that we would work through. They, in effect, provide a multiplier benefit. The liaison office, when it receives a request from a local center either through a State or directly, instead of having to maintain a full list of every type of vendor, every type of consultant and so on in the country, will by this plan be able to go to the appropriate trade association which, in turn, will have an office and maintain its list of all the vendors and all the consultants who are willing to help these small technology transfer centers.

And with that multiplier effect, then, we have a very quick circuit going from the—a communications circuit—going from a local technology center to the ultimate vendor, and then a very quick return. So, we have set up an arrangement here where these two different worlds can be brought together.

At the same time, we have commenced conversation with the Department of Commerce. We had a meeting with Dr. Ambler and some of his people, with the idea that this liaison office could interface in some manner with the Department of Commerce to achieve two ends:

One, it would enable this group to gain the benefit of all the various Federal programs that are in place to help small companies, to be able to communicate that information on to the appropriate people, and at the same time sort of like an hourglass, this whole thing could be turned upside down and the automation group, the liaison office, would be able to feed useful information to the Department of Commerce as to what is going on out there.

So, this plan for a communications network utilizing existing activities is still in the development stage. The local center people we have talked with, the State Government people we have talked with in Pennsylvania, the trade association executives we have

talked with—and this is primarily the National Machine Tool Builders Association; NEMA, the National Electrical Manufacturers Association; MHI, the Material Handling Group; and the RIA, the robotics group which represent a large percentage of the hardware vendors; and the hardware and software vendors themselves that we have talked with—are all acutely aware of this problem and are enthusiastic about this plan.

We are also, as I mentioned a minute ago, discussing the plan with people at the Department of Commerce. After a recent meeting with Dr. Ambler, Acting Undersecretary for Technology, and some of the people from NIST and from the Office of Commercial Affairs and the Technology Administration, their response to this plan is also enthusiastic.

What we are doing now with the resulting Department of Commerce ad hoc committee is to determine a way in which the liaison office can interface effectively with the Federal Government. So, this program can appropriately take advantage of existing Federal programs and, in turn, feed useful activity information back through to the interested Government bodies.

In summary, we see this as a communications network which interfaces with the Department of Commerce, which informs all segments of the network, gains an important multiplier benefit from the trade association and State and regional participations, effectively brings the vendor community and local transfer centers together on an as-needed basis, and in its overall is a private sector initiative which will gain from fully appropriate Government participation.

While this program is still in its formative stages, I appreciate this opportunity to lay our plan before you, as I am convinced that any Federal support or monitoring program, to be effective, will have to reach into every local community and to do so, it should consider working in concert with some program such as we have presented today.

Thank you.

[The prepared statement of Mr. Richardson follows:]

MANAGING automation

# TESTIMONY TO THE SUBCOMMITTEE ON SCIENCE, RESEARCH & TECHNOLOGY

By
Ralph E. Richardson
March 23, 1989

MANAGING automation
THE MANAGEMENT MAGAZINE OF COMPUTER INTEGRATED MANUFACTURING
A THOMAS PUBLICATION/ELEVEN PENN PLAZA/NY, NY 10001/212 [illegible]

Mr. Chairman, members of the subcommittee.... My name is Ralph Richardson and I am the Group Publisher of Managing Automation, of Industrial Equipment News, and of Inbound Logistics, all industry magazines published by Thomas Publishing Company.

I thank you for giving me this opportunity to put before you a plan for helping small and midsized manufacturing companies to become more competitive.

I speak to you as the representative of an informally organized group of automation equipment and software producers, and trade associations officers.

Before I describe this plan and the steps we are taking to try to turn it into a functioning program, I should first say that my written testimony describes the nature and extent of the problem in sore depth.

By way of a precis of that testimony, I should like here to say...
...That as with every other industrialized nation, we enjoy an interdependent network of small to large manufacturing enterprises, every segment of which is essential to the whole
..That in our new, fiercely competitive global economy, it is essential that all manufacturers adopt some degree of the new, advanced manufacturing technologies and their attendant improved organizational processes and management methods
...That the very largest American manufacturers have so adopted these new technologies
...But that because of particular conditions which are described in the written testimony, our small and midsized manufacturing companies have largely failed to adopt these technologies and are therefor clearly falling behind their foreign counterparts in their ability to compete here as well as overseas.
It is ironic that while we, as a society, have poured unmeasured wealth into technology development, we have failed to take reasonable steps to employ these technologies for our benefit. As you well know, the rest of the industrial world has not so failed to use our technological developments. Every country in Europe and every industrialized nation in the Orient has programs of direct help for their small manufacturers. Some of these programs are also outlined in my written testimony.

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What, then, is to be done about our failure in technology transfer?

Our group has developed a plan which we believe is in keeping with the American way of doing things. It is a private sector initiative which ties existing activities into a communications network aimed at bringing realistic help to these small companies on an "as needed" basis.

It is a plan which will connect existing private sector, State, academic and local activities to each other and in turn to those federal government activities which pertain to this problem.

The plan is based on the conviction that the best hope for solution is appearing at the local level, often with State assistance, in the form of technology transfer centers. Their function is to reach out to the small and midsized companies in their areas to help them adopt existing, off the shelf automation technologies. This help most often extends to planning and training, both management and worker, as well as to equipment assistance.

I should make special effort here to emphasize that our plan is referring to those local technology transfer activities centers which are aimed at helping small companies become more competitive through training and through the adoption of off the shelf technologies.

We are not talking about the several other types of technology development and transfer such as advanced simulation or vision technology development, or of finding ways to move leading edge technologies out of the laboratories into commercial application. These are critical jobs to be done, but they are not the need we are addressing.

Our centers are, for the most part, setting up advanced production facilities for both hands on demonstration purposes as well as for training purposes. They often need help in designing these facilities and in obtaining specific equipment from vendors. They also need help in designing and implementing training programs and in providing automation planning consultation.

It is the intent of our plan to help all of these local centers perform their functions. This triangle graphic can best portray this network plan. (See Fig. 1)

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This plan for a communications network utilizing existing activities is still in the development stage. The local center people we have talked with, the State government people we have talked with in Pennsylvania, the Trade Association executives we have talked with at NMTBA, NEMA, MHI and RIA, and the hardware and software vendors we have talked with are all acutely aware of this problem and are enthusiastic about this plan.

We are, also, discussing this plan with people at the Department of Commerce. We had a meeting recently with Dr. Ambler, Acting Undersecretary for Technology, and some of the people from NIST and from the Office of Commercial Affairs in the Technology Administration. Their response to this plan is also enthusiastic. What we are doing now with a resulting DoC Ad Hoc committee is determining a way in which the liaison office can interface effectively with the federal government so that this program can appropriately take advantage of existing Federal programs and in turn feed useful activity information back through to the interested government bodies.

In summary, we see it as a communications network which interfaces with the Department of Commerce Technology Administration, which informs all segments of the network, gains an important multiplier benefit from the Trade Association and State and Regional participations, effectively brings the vendor community and local transfer centers together on "as needed" basis, and in its overall is a private sector initiative which will gain from fully appropriate government participation.

While the program is still in its formative stages, I appreciate this opportunity to lay our plan before you as I am convinced that any Federal support or monitoring program to be effective will have to reach into every local community and to do so it should consider working in concert with some program such as we have presented today.

Thank you.

# Technology Communication Network

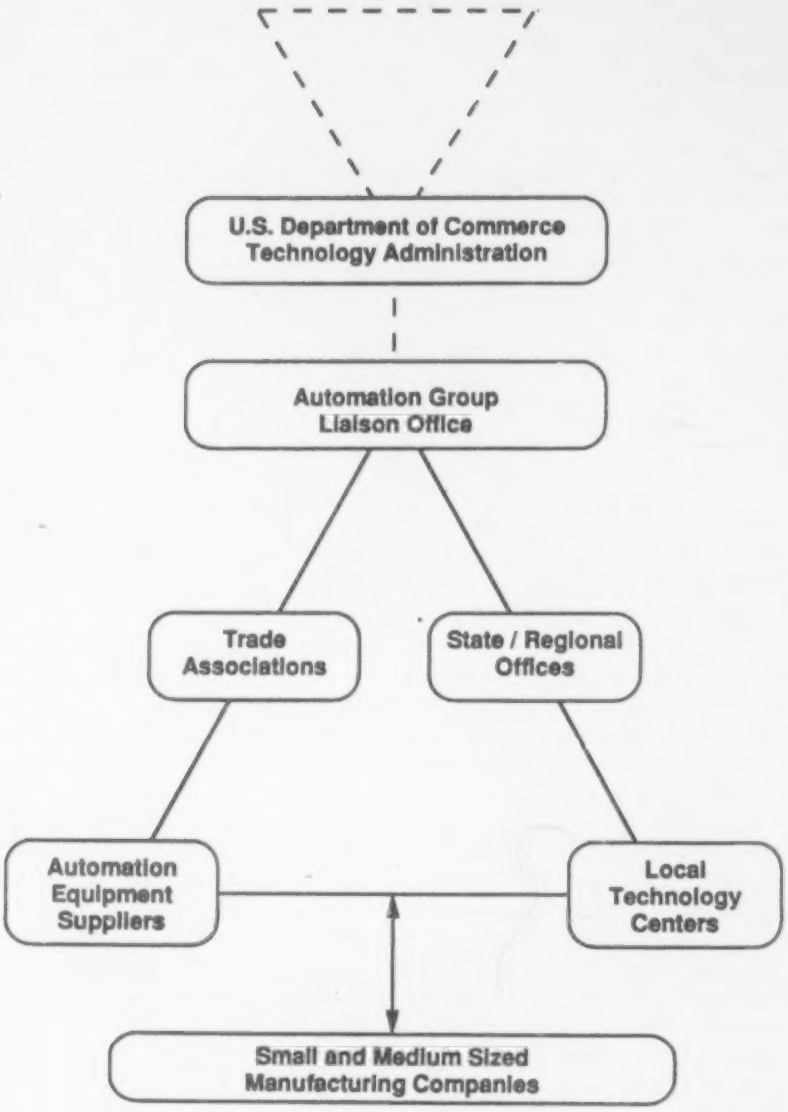


FIGURE 1

Mr. WALGREN. Thank you very much, Mr. Richardson.

Let's turn to Mr. Ling, who is the chairman of the American Society of Mechanical Engineers.

Mr. Ling?

## STATEMENT OF FRED LING, CHAIRMAN, AMERICAN SOCIETY OF MECHANICAL ENGINEERS/NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY INTERACTION COMMITTEE

Mr. LING. Good morning, Chairman Walgren, and distinguished members of the Science Research and Technology Subcommittee. My name is Fred Ling, and I am director of Columbia's Engineering Productivity Center at Columbia University.

I am appearing before you today in my capacity as Chairman of the American Society of Mechanical Engineers/National Institute of Standards and Technology Interaction Committee. We are delighted to have this opportunity to present our views on the Administration's fiscal '90 budget request for the National Institute of Standards and Technology, founded in 1880.

ASME's membership of more than 116,000 engineers, including some 20,000 students, practice in many applications of engineering. As a result, we have a strong and continuing history of interest in both the immediate and long-term direction of NIST. In fact, NIST has just released a report which outlines several areas of interaction between NIST and ASME. A copy of this report is appended to our testimony, and we request that it be included with our full written statement in the record of this hearing.

I would like to thank each of the committee members who supported the Technology Competitiveness Act of 1988, which significantly expanded the mission that was formerly the National Bureau of Standards. While the name change is probably the most visible of all the legislative changes, the Competitiveness Act also gives NIST a host of new responsibilities.

The number one priority, however, remains the same: to work closely with industry on the development and use of new technologies that U.S. companies need to stay competitive in the world marketplace. In this regard, one of the most important aspects of NIST's work is in technology transfer. In order to commercialize new technologies, standards must usually be developed. Standards provide the basis for technology transfer because they allow companies to manufacture products based on proven specifications.

Despite all the actions which signalled the increased interest and responsibility of NIST, funding for NIST has not kept pace with the level of responsibility it is being asked to assume.

Therefore, we are greatly concerned that without increased funding, NIST will be forced to cut its critical ongoing work to pay for new programs. We would like the Administration to commit itself to a far-reaching, long-term growth plan for NIST, as it has for the National Science Foundation.

While ASME went on record as favoring funds for the regional centers for the transfer of manufacturing technology, we do not support the manner in which the $7.5 million in funds were earmarked by the House Appropriations Committee for this activity in the NIST budget. Likewise, the $7.5 million for nondestructive

evaluation center grant, which was not in the budget request, was at the expense of proposed initiatives in other important programs.

For the seventh year in a row, the NIST budget proposal has called for drastic cuts in the fire and building research programs. We strongly disagree with the Administration's contention that this important work will be picked up by the private sector.

We are quite pleased, however, by the proposed $700,000 increase for the high-temperature superconductor program. Building on funding for fiscal '88, NIST is fulfilling its role specified in the superconductivity initiative. Among other things, that initiative calls for NIST to develop superconductor standards and establish a superconductivity center at NIST for electronic applications.

We also are in favor of the $2.6 million requested for the light wave measurement technology program. Mechanical engineering is involved in virtually all aspects of light wave technology. NIST has already provided the measurement basis for 25 voluntary industry measurement standards that support the development and sale of optical fibers. It has been estimated that the economic benefit of this program will reach between $100 and $200 million per year in the next decade.

We are also very much interested in the bioprocess engineering program and support its proposed increase of $2.3 million. Mechanical as well as chemical engineers will be faced with many challenges by new and emerging technologies related to the biotechnology field.

Last but not least, we would like to go on record in supporting the two-year budget authorization. This will allow for better long-range planning and eliminate much of the guesswork that currently takes place with the yearly authorization.

Long-term planning is absolutely critical to meeting many of the technology and competitive challenges that the U.S. faces today. As you know, the Western European countries plan to incorporate their markets into a single integrated market by the end of 1992.

There is considerable concern in the United States regarding differing national technical standards and their implications for U.S. exporters to Europe. This area could have significant impact not only on the standards work on this, but all the competitiveness area outlined here today.

This concludes my testimony, Mr. Chairman.

[The prepared statement of Mr. Ling, plus the NIST report follows:]

The American Society of Mechanical Engineers

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202-785-3756

Statement of the

Task Force on the National Institute of Standards and Technology

of the

American Society of Mechanical Engineers

on the

National Institute of Standards and Technology

FY 1990 Budget Request

Before the

Subcommittee on Science, Research and Technology

Committee on Science, Space and Technology

U.S. House of Representatives

March 23, 1989

Good Morning Chairman Walgren and distinguished members of the Science Research and Technology Subcommittee.

My name is Fred Ling and I am Director of the Columbia Engineering Productivity Center at Columbia University. I am appearing before you today in my capacity as chairman of the American Society of Mechanical Engineers/National Institute of Standards and Technology Interaction Committee. My comments represent the consensus of that group rather than an official position of ASME.

We are delighted to have this opportunity to present our views on the Administration's Fiscal Year (FY) 1990 budget request for the National Institute of Standards and Technology. Founded in 1880, ASME's membership of 116,400 engineers which includes 19,200 students, practice many applications of engineering. As a result, we have a strong and continuing history of interest in both the immediate and long term direction of NIST.

In fact, NIST has just released a report which outlines several areas of interactions between NIST and ASME. A copy of the report is appended to our testimony and we request that it be included with our full written statement in the record of this hearing.

I would also like to thank each of the committee members who supported the Technology Competitiveness Act of 1988, which significantly expanded the mission of what was formerly the National Bureau of Standards. While the name change is probably the most visible of all the legislative changes, the Competitiveness Act also gave NIST a host of new responsibilities. The number one priority, however, remains the same: to work closely with industry on the development and use of new technologies that U.S. companies need to stay competitive in the world marketplace.

In this regard, one of the most important aspects of NIST's work is technology transfer. In order to commercialize new technologies, standards must usually be developed. If the necessary standards do not exist, they must be developed and tested. Therefore, the importance of standards cannot be overemphasized in industrial competitiveness. Standards provide the basis for technology transfer because they allow companies to manufacture products based on proven specifications.

NIST plays a key role in this area of standards and technology transfer and we hope their efforts in this regard will continue and be strengthened.

However, despite all the actions which signal the increased interest and responsibilities of NIST, the FY 1990 budget request calls for an overall budget reduction of nearly $4 million, falling to $155.6 million from the $159 million FY 1989 appropriation. Funding for NIST has not kept pace with the level of responsibility it has been asked to assume. Therefore, we are greatly concerned that without increased funding, NIST will be forced to cut its critical on-going work to pay for the new programs. Ideally, we would like the Administration to commit itself to a far-reaching, long-term growth plan for NIST, as it has for the National Science Foundation.

In FY 1988, Congress appropriated $144.8 million for NIST. In FY 1989, NIST requested $158 million from Congress--and received $159 million. However, it should be noted that the $159 million included $15 million for program activities that were not included in the budget request. As a result, in FY 1989 the portion of its budget which is directed to the traditional NIST activities is only $144 million.

While ASME went on record as favoring funds for the Regional Centers for the Transfer of Manufacturing Technology, formerly known as the Hollings Centers, we do not support the manner in which $7.5 million in funds were "earmarked" by the House Appropriations Committee for this activity in the NIST budget. Likewise, the $7.5 million for an NDE Center grant, which was not in the budget request, was at the expense of proposal initiatives and other important programs. Funding for the newly authorized programs should be in addition to funding for the base programs and new technical activities. If we continue to fund the newly authorized programs at the expense of the base technical programs and initiatives, NIST programs will suffer and they will not be able to address the important technical issues associated with emerging technologies which are critical if we are to further our Nation's industrial competitiveness.

We would now like to turn our attention to specific areas of the NIST budget. We will concentrate our comments on the areas of proposed increases and decreases in the budget. Please do not assume that the areas we do not address are not

important. In the interest of time, we will limit ourselves to the major changes in the budget.

ASME certainly understands and appreciates the vital role that NIST plays in the technological battle currently being waged, particularly between the U.S. and Japan. Their work is especially important since as previously discussed, NIST not only conducts research, but plays a vital role in moving research out of the laboratory into the hands of industry. But again, I want to emphasize that new NIST activities should be funded adequately on their own merits, and not at the expense of important "core" programs.

For example, for the seventh year in a row, the NIST budget proposal has called for drastic cuts in the fire and building research programs. We strongly disagree with the Administration's contention that this important work will be picked up by the private sector. Unfortunately, the debate on fire and building research has become an annual event. As a result, time and attention needed to save these programs have diverted attention from other areas of the NIST budget with which Congress should be concerned. Nonetheless, we once again join in this debate and ask that you reject the proposed cut of $3.9 million and fund the fire and building programs at a level consistent with previous years.

Another area of concern is the elimination of another fire and building research program, searching for alternative refrigerants. The proposed cut of $250,000 comes at a time when we are faced with an urgent need to replace widely-used refrigerants that damage the stratospheric ozone layer. While the budget proposal states that "this program is inconsistent with funding priorities for NIST for FY 1990"--we think it is consistent--and should be continued.

We are quite pleased, however, by the proposed $700,000 increase for the High Temperature Superconductors program. Building on funding from FY 1988, NIST is fulfilling its role specified in the Superconductivity Initiative. Among other things, that initiative called for NIST to develop superconductor standards, and establish a superconductivity center at NIST for electronic applications. The superconductivity center has already been put to its test. With the discovery of high temperature superconductors, NIST introduced the first superconducting

measurement device (SQUID). SQUID, a superconducting quantum interference device, is capable of operating at liquid nitrogen temperatures and is fully recognized as a measurement device.

As you know, world-wide competition to develop and market products based on superconductivity is extremely fierce. NIST can and must provide the necessary research on measurements and standards related to superconductivity to speed the commercialization of superconductors and help assure the U.S. competitive position. We strongly support this programmatic increase.

We also are in favor of the $2.6 million requested for the Lightwave Measurement Technology Program. Mechanical engineering is involved in virtually every aspect of lightwave technology. NIST has already provided the measurement basis for 25 voluntary industry measurement standards that support the development and sale of optical fibers. It has been estimated that the economic benefits of this program will reach $100-200 million per year in the next decade.

We are also very much interested in the Bioprocess Engineering program and support its proposed increase of $2.3 million. Mechanical, as well as chemical engineers will be faced with many challenges by new and emerging technologies related to the biotechnology field. While there is general agreement that the U.S. currently leads in fundamental biochemical research in the laboratory, we must improve our capability to move this technology into the marketplace. NIST can play a key role in developing the necessary measurements and standards which will allow the U.S. to be competitive in the many commercial applications of bioprocess engineering. We support NIST's activities in this area.

We would also like to go on record as supporting a two-year budget authorization for NIST. This would allow for better long-term planning and eliminate much of the guess work that currently takes place with a yearly authorization. Long-range planning is absolutely critical to meeting many of the technology and competitive challenges that the U.S. faces today. For example, as you know, the Western European countries plan to incorporate their markets into a single integrated market by the end of 1992. There is considerable concern in the United States regarding differing national technical standards and their implications for U.S. exporters to

Europe. This area could have a significant impact not only on the standards work at NIST, but in all of the competitiveness areas outlined here today.

This concludes my testimony, Mr. Chairman. Thank you again for the opportunity to express our views to the Subcommittee. I will be happy to answer any questions you or the other Members may have.

NISTIR 89-4038

# Report on Interactions Between the National Institute of Standards and Technology and the American Society of Mechanical Engineers

Gail K. Ehrlich

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(Formerly National Bureau of Standards)
National Engineering Laboratory
Gaithersburg, MD 20899

February 1989

National Bureau of Standards became the National Institute of Standards and Technology on August 23, 1988, when the Omnibus Trade and Competitiveness Act was signed. NIST retains all NBS functions. Its new programs will encourage improved use of technology by U.S. industry.

**U.S. DEPARTMENT OF COMMERCE**
**Robert A. Mosbacher, Secretary**

**Ernest Ambler, Acting Under Secretary for Technology**

**NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY**
**Raymond G. Kammer, Acting Director**

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# REPORT ON INTERACTIONS BETWEEN THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY AND THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS


## Abstract

This report highlights examples of interactions between the National Institute of Standards and Technology (NIST) and the American Society of Mechanical Engineers (ASME) over the past several years. It is meant to be representative, not all-inclusive. The interactions are organized by discipline in the following categories: Conferences, Committee Memberships and Contribution to Standards, Editors, Publications, Honors and Awards, and Special Activities. The report illustrates many activities which are designed to disseminate NIST's most recent technical advances and to learn of the technical challenges facing engineers in industry.


Requests for information, comments, as well as additions and revisions, are welcome. Please contact:


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Key Words: ASME; computers; heat transfer; mechanical engineering; pressure vessel piping; robotics; solar energy; standards; technology transfer; tribology

## 1. INTRODUCTION

In this era of rapid technological change, the National Institute of Standards and Technology (NIST)[1] and the American Society of Mechanical Engineers (ASME) maintain a synergistic relationship that benefits the engineering profession and the Nation. NIST is the Nation's central reference laboratory for physical, chemical, and engineering measurements. In addition, the Omnibus Trade and Competitiveness Act of 1988 expanded NIST's mission to further assist industry in the development of technology and procedures needed to improve quality, modernize manufacturing processes, ensure product reliability, manufacturability, functionality, and cost-effectiveness, and to facilitate the more rapid commercialization of products based on new scientific discoveries. NIST is the only major Federal laboratory with a direct mission to support American industry.

ASME is a nonprofit technical and educational organization with approximately 118,000 members nationwide working in industry, government and academia. The Society has more than 200 local Sections covering all 50 states and 34 technical divisions representing a broad diversity of engineering expertise. The ASME plays an important role in NIST's efforts to fulfill its mission. Technical conferences and publications sponsored by the ASME provide a forum for NIST staff to disseminate their most recent technical advances and in turn to learn of the technical challenges facing engineers in industry. NIST staff contribute to the development of ASME standards as these standards are an effective means of assuring that technical advances are incorporated in industrial practice.

NIST has had extensive interactions with ASME for many years. Peer relationships in many technical areas have led to these interactions which are distributed throughout the NIST organization. Likewise, within ASME many of the committees and technical divisions have been interacting with NIST.

In 1985, ASME formed a Committee to increase interactions between NIST and ASME. ASME recognized the extensive on-going activities underway between the two organizations and stressed that the new Committee's work will not disrupt or interfere with these on-going activities. On the contrary ASME and NIST agreed to use these on-going activities as models to expand the relationship in other areas of mutual interest. In preparation for the first Committee meeting in August 1985, a report was prepared to summarize ASME/NIST interactions. It has been periodically updated.

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[1]The National Bureau of Standards (NBS) became the National Institute of Standards and Technology (NIST) on August 23, 1988, when the President signed the Omnibus Trade and Competitiveness Act. NIST retains all of the NBS functions in addition to new programs that will further encourage improved use of technology by U.S. industry.

In view of this change in the name, the ASME/NBS Interactions Committee has been redesignated as the ASME/NIST Interactions Committee. The abbreviations NBS and NIST are both used in this report depending on the time of the activity being reported.

## 2. SUMMARY OF ACTIVITIES

This report is meant to be representative, not all-inclusive. It excludes general Society membership.

The NIST/ASME activities are summarized in the following categories:

Conferences
Committee Memberships and Contributions to Standards
ASME Editors
Publications
Honors and Awards
Special Activities

Details of these activities are contained in Appendix A of this report and are organized by the appropriate NIST working unit. A summary of these activities follows.

Conferences

Recently, NIST scientists and engineers have participated as session chairmen, co-chairmen, organizers, and panel members in over 35 ASME conferences, meetings, symposiums, and workshops. For example, they have been very active in many of the Winter and Summer Annual Meetings, the National Heat Transfer Conferences, Computers in Engineering Conferences, and the Solar Energy Division Conferences. In addition, over 90 papers by NIST authors have been presented at ASME conferences and meetings.

Committee Memberships and Contributions to Standards

Over the past few years, NIST scientists and engineers have been active in over 30 ASME committees and subcommittees and hold such positions as chairman and vice-chairman.

As a result of NIST research and coordination with ASME committee members, several significant standards and measurement practices have been adopted. For example, based on major input from the members of the Heat Transfer in Electronic Equipment Committee, as well as industry and academia, the 1987 Book of Semiconductor Equipment and Materials International (SEMI) Standards published the first standardized approach for using a wind-tunnel for forced-air convection testing of microelectronic devices. NIST participation in the Committee on Surface Roughness helped to carry out two major revisions of the surface roughness standard. A standard for the Coordinate Measurement Machine was also developed in the Coordinate Measuring Machine Performance Evaluation Committee in which two NIST engineers are members. Progress in PDES and IGES has also been advanced as the result of ASME and NIST interactions in the Computer Representation of Product Definition Data Committee.

ASME Editors

Dr. John W. Lyons, the Director of NIST's National Engineering Laboratory, is an Editorial Advisor for ASME's Manufacturing Review. In addition, other NIST researchers have served as associate editors and engineering reviewers for several ASME journals.

Publications

In addition to the numerous papers published in conference proceedings, the NIST technical staff has contributed more than 20 articles in the following major ASME publications: Mechanical Engineering, the Journal of Computers in Mechanical Engineering, the Journal of Engineering for Industry, the Journal of Solar Energy, the Journal of Heat Transfer, and ASME NEWS.

Honors

In 1986, ASME recognized Jeffrey Fong as an ASME Fellow. The ASME Council on Engineering honored him with a Distinguished Lectureship in 1988 and he received a Certificate of Appreciation from the Board of Governors in 1987.

Special Activities

NIST participates in the ASME National Laboratory Technology Transfer Committee with the purpose of promoting technology transfer to the ASME membership.

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We wish to acknowledge the support and work of Nate Hurt who, until this year when he became a member of the ASME Board of Directors, served as Chairman of the ASME/NIST Interactions Committee since its establishment in 1985. His personal efforts and commitments have resulted in both NIST and ASME gaining a better understanding of the respective organization's programs and interests.

# APPENDIX A

## EXAMPLES OF

## NIST/ASME INTERACTIONS

## NATIONAL ENGINEERING LABORATORY

### OFFICE OF THE DIRECTOR

Conferences:

1987 ASME Summer Annual Meeting, Toronto, Canada

- Samuel Kramer - Participated in three ASME committee meetings to present an overview of NBS and to explore opportunities for new collaborative efforts.

ASME Committee Memberships:

ASME/NIST Interactions Committee

- Samuel Kramer - Organized meetings at NIST.

ASME National Laboratory Technology Transfer Committee

- Samuel Kramer - Serves as the NIST representative and attended committee meetings held in Washington, DC on Nov. 6, 1987, and at the MI88 Conference in Atlanta, GA on July 26, 1988. The purpose of these meetings was to discuss how the DoE national labs and NIST can promote technology transfer.

- NIST technology transfer activities described in "Transferring 'Taxpayer' Technology," ASME NEWS, May 1988.

- Mechanical Engineering, Technology Transfer Issue, Sept. 88.
  - Jones, A. and Mattson, B. "Tomorrow's Factories Today." This article describes NIST's program in automated manufacturing and its technology transfer.
  - NIST staff provided a description of their research in other areas of interest to the National Laboratories for inclusion in the following technology transfer articles: "In Search of New Materials," High Performance Buildings," and "A User's Guide to the National Labs."

ASME Editor:

Manufacturing Review

- John W. Lyons, Editorial Advisor

Other ASME Publications:

- Lyons, John W., "Coming Up With New Products that Beat the Odds," Mechanical Engineering, Managing Technology Issue, April 1988.

Special Activities:

ASME Day at NIST, February 17, 1988

- Samuel Kramer and Gail Ehrlich organized this meeting attended by more than 30 ASME members. The one-day meeting included presentations, tours, and discussions covering major technical activities at NIST which are of interest to mechanical engineers. Dr. John W. Lyons, Director, NEL, participated in a question and answer session at the end of the day.

## NATIONAL ENGINEERING LABORATORY

### CENTER FOR MANUFACTURING ENGINEERING (CME)

Conferences:

Spring 1989 Design Conference
- o T. Kramer - Paper presentation at the CAD/CAM/CAE session.

1988 ASME Winter Annual Meeting
- o Algeo, M.B. and Hopp, T.H., "What is a Tolerance: The Problem of Methods Divergence in Flexible Automation."

September 1988 Workshop on Mechanical Tolerancing
- o T. Hopp - Session Co-chair on Inspection Methods and Machines.

August 1988 Computers in Engineering Conference, San Francisco, CA
- o Meunier, K., "Iterative Respecification: A Computational Model for Hierarchical Mechanical System Design."

April 1988 Manufacturing International (MI 88), Atlanta, GA
- o T. Kramer - Session Co-chair, "Design and Planning of Manufacturing Systems II."

1987 ASME Winter Annual Meeting
- o A. Donmez - Session Chairman of Quality Issues in Measurement and Inspection.
- o Lee, J.D., Haynes, L.S., Wang, B.L., and Tsai, K.H., "Control of Flexible Robot Arm," presented and published in Modeling and Control of Robotic Manipulators and Manufacturing Processes.

December 1987 Symposium of Integrated Intelligent Manufacturing: Analysis and Synthesis
- o Kramer, T., "Process Planning for a Milling Machine from a Feature-Based Design."
- o Kramer, T., Strayer, W.T., "Error Prevention and Detection in Data Preparation for a Numerically Controlled Milling Machine."
- o Nakpalohpo, I., Jun, J., "Automated Equipment Program Generator of the AMRF Vertical Machining Workstation."

May 1987 26th Technical Symposium on New Trends in Automated Manufacturing
- o Swyt, D.A., "Data-Driven Flexibly Automated Manufacturing: The View from NBS."

December 1986 Symposium of Integrated Intelligent Manufacturing: Analysis and Synthesis
- o McLean, C., "Vertical Workstation of the AMRF: Software Integration."
- o Magrab, E., "Vertical Workstation of the AMRF: Equipment Integration."
- o McLean, C., "Interactive Process Planning in the AMRF."

1986 ASME Winter Annual Meeting
- Slocum, A., Greenspan, L., and Peris, J., "Design and Implementation of a Five Axis Robotic Micromanipulator."
- Slocum, A., Yee, K., Peris, J., and Jurgens, P., "A Servo-controlled Pneumatic Double Gripper with Changeable Fingers."
- Donmez, A., Liu, R., Barash, M., "A Generalized Mathematical Model for Machine Tool Errors."

1986 ASME International Computers in Engineering Conference and Exhibition
- H. Bloom - Discussed software standards with ASME Committee chaired by Dr. Raghaven.
- P. Brown - Session Chairman, Robotics I - Manipulation.
- H. Bloom and C. McLean - Paper presentation.

September 1985 ASME Design Technology Conference
- C. McLean - Panel member.

August 1985 ASME Board of Governors, Manufacturing Sciences Program Meeting
- R. Hocken (Former NIST employee)

1985 ASME International Computers in Engineering Conference and Exhibition
- H. Bloom - Keynote Speaker.
- C. McLean - Chairman of Expert System Session.
- C. McLean and A. Jones - Paper presentation.

August 1984 ASME International Computers in Engineering Conference
- C. McLean - Panel member of Expert System Session.
- C. McLean and A. Jones - Paper presentation.

August 1983 ASME International Computers in Engineering Conference
- C. McLean - Chairman of Flexible Manufacturing Systems Session.

ASME Committee Memberships and Contributions to Standards:

B46 - Committee on Surface Roughness
- T.V. Vorburger, Chairman
- C. Teague
- Participated over past 10 years and helped to carry out two major revisions of the surface roughness standard.
- These members are in the process of formalizing a proposal to ASME and the Committee that ASME be the U.S. sponsor or participating sponsor to support the data collection to form the National/International Surface Roughness Data Bank.

Pressure Vessel Codes - Acoustic Emission
- F. Breckenridge

Y14.26 - Computer Representation of Product Definition Data
- B. Smith
- This committee and its parent committee Y14, Engineering Drawings and Related Practices, form the route for ANSI's review and approval of the NIST projects on the Initial Graphics Exchange Specification (IGES) and the Product Data Exchange Specification (PDES).

- IGES Version 3.0 was submitted in June 1986 and has been approved in three rounds of balloting. It was approved as an American National Standard in September 1987. IGES Version 4.0 will be submitted by April 1989.
- A method of electronic exchange of ASME standards submissions and of looseleaf publication of this work has been worked out with ASME staff.
- The first working draft of PDES will be submitted to Y14.26 by December 1988.

B5 - Machine Tool-Components Elements, Performance and Equipment
- Denver Lovett
- Preparing proposed performance standards for machining centers.
- Advising and assisting ASME on the establishment of a new committee on machining centers.

B5-TC52 - Machining Centers Committee
- Denver Lovett

B89.1.12 - Coordinate Measuring Machine Performance Evaluation
- Bruce Borchardt
- Theodore Hopp
- Coordinate Measurement Machine standard worked in consensus with this committee.

B89.1.5 - Master Disks, Plug Gages, Spherical Standards and Thread and Gage Wires
- Ralph Veale

B89.1.6 - Master Ring Gages
- Ralph Veale

Other ASME Publications:

- Roche, M., "Using Available Curve-Shaped Information with a Non-Uniform B-Spline," Computers in Mechanical Engineering, July/August, 1987.
- Lee, J.D., Haynes, L.S., "Finite Element Analysis of Flexible Fixturing System," Journal of Engineering for Industry, 1987.
- Eitzen, D. - prepared article on NBS conical transducer for Mechanical Engineering, Fall, 1985.

NATIONAL ENGINEERING LABORATORY

CENTER FOR COMPUTING AND APPLIED MATHEMATICS (CCAM)

Conferences:

June 1988 Applied Mechanics and Engineering Sciences Conference, Berkeley, CA
- o T. Burns - Session Chairman on "Plasticity."
- o Burns, T., "Similarity and Bifurcation in Unstable Viscoplastic Shear."

Jeffrey T. Fong's extensive conference activities follow:

September 1988 6th International Conference on Pressure Vessel and Piping Technology (ICPVT-6), Beijing, China
- o Technical Program Chairman for the American Region (co-sponsored by ASME).

June 1988 Pressure Vessel Piping Conference, Pittsburgh, PA
- o General Chairman.
- o Co-chairman of Panel technical session on "PVP Code Requirements for the Emerging Bioprocessing Industry."
- o Tutorial Leader of "PC-Based Expert Systems for Managing Engineering Data."

October and June 1987 ASME Pressure Vessel Piping Conference, Knoxville, TN
- o Tutorial Leader on "How to Manage Engineering Data with a PC."

July 1986 ASME Pressure Vessel Piping & Computer-in-Engineering Joint Conference, Chicago, IL
- o Technical Program Co-chairman
- o Tutorial Leader on "How to Manage Engineering Data with a PC."
- o Session Chairman on "U.S. Competitiveness in a Computer-Dominated World Economy" (Invited Speaker: The Hon. Clarence Brown, Deputy Secretary, U.S. Department of Commerce).

June 1984 ASME-ASIS-MPC-NBS Symposium on "Engineering Databases: Software for On-Line Applications," San Antonio, TX
- o Symposium Chairman & Editor of Proceedings as ASME publication PVP-96.

June 1983 ASME-ASNT-NBS-PVRC Symposium on "NDE Reliability Through Round Robin Testing," Portland, OR
- o Symposium Chairman and Editor-in-Chief of Proceedings as ASME publication NDE-1.

ASME Committee Memberships (J. Fong):

ASME Materials and Structures Technical Group
- o Chairman, Meetings and Publications Committee, 1988-1989
- o Board Member, 1987-1989

Pressure Vessels and Piping Division
- o Senate President, 1988-1989
- o Chairman, 1986-1987
- o Vice-Chairman and Chairman-Elect, 1985-1986
- o Executive Committee Member, 1982-1985

ASME Technical Opportunities and Planning Committee
- o 1985-1987

Elasticity Committee, Applied Mechanics Division
- o 1982-1986

ASME/NBS Interactions Task Force
- o 1984-1985

ASME Editor (J. Fong):

Board of Editors for ASME Journal of Pressure Vessel Technology
- o Associate Editor, 1983-present

Board of Editors for ASME Journal of Computers in Mechanical Engineering (CIME)
- o Associate Editor, 1984-1986

Other ASME Publications:

- o Fong, J.T. and Filliben, J.J., "A Data Analysis Methodology as Applied to the PVRC Round Robin NDE Test Program," ASME spec. pub. NDE-1, 1986.
- o Fong, J.T., "Analysis of Sectioning Data of PVRC 251-J for Estimating Flaw Fabrication Reliability," ASME pub. NDE-1, 1986.
- o Fong, J.T., co-edited with Mordfin, L., Hedden, O.F., and Bush, S.H., "NDE Reliability Through Round Robin Testing," ASME spec. pub. NDE-1, 1986.
- o Chapman, R., "Applications of Operations Research Techniques to System Design and Evaluation," ASME spec. pub. PVP-109, 1986.
- o Fong, J.T., co-edited with Hollinger, G.L., Gowda, B., Ezekoye, L., and Levary, R., "ASME Codes & Recent Advances in Pressure Vessel, Piping, and Valve Technology," ASME spec. pub. PVP-109, 1986.
- o Fong, J.T., "Integration of Analysis and Data Bases for Decision Making," CIME, July, 1986.
- o Fong, J.T., Cramer, R.S., and Redmiles, D.F., "DATAX: A Prototype Software for Engineering Data Evaluation and Decision Support (Extended Abstract)," ASME spec. pub. PVP-96, 1984.

- Redmiles, D.F., "K*: A Fortran-Based Code for Programming and Evaluating Interactive Software, "ASME pub. PVP-96, 1984.
- Filliben, J.J., and Fong, J.T., "DATAPLOT as an Expert System for Interactive Data Analysis," ASME spec. pub. PVP-96, 1984.
- Fong, J.T., ed., "Engineering Databases: Software for On-Line Applications," ASME spec. pub. PVP-96, 1984.
- Fong, J.T., "Computer Software Needs of Materials Property Data Bases for Selected Engineering Applications," ASME spec. pub. MPC-20, 1983.

Honors and Awards:

- Jeffrey T. Fong - Distinguished Lectureship (1988-90) from ASME Council on Engineering, March 1988. The Distinguished Lecturers Program was established by ASME in 1987 as an organized endeavor designed to provide Regions and Sections with an opportunity to hear from outstanding speakers at the leading edge of their technology. Only candidates with exceptional credentials and a proven ability to communicate their insights and excitement to a diverse engineering audience have been invited to participate.

- Jeffrey T. Fong - Certificate of Appreciation from ASME Board of Governors, July 1, 1987. Recognized for his valuable services to ASME in advancing the engineering profession as a member and chairman of the Pressure Vessels and Piping Division Executive Committee.

- Jeffrey T. Fong - ASME Fellow, July 1986. Recognized "for distinguished contribution to the advancement of the arts and sciences of mechanical engineering practice through research, publication, consulting, and conference management."

Special Activities (J. Fong):

China National Standards Committee of Pressure Vessel

- Honorary Advisor, PRC State Bureau of Standards, Bejing, China, 1985-1987.
- Special Assistant to ASME Executive Director and Managing Director for Codes and Standards for planning the hosting of official visit to the U.S. by this Committee, 1985-1986.
- Special Assistant to ASME President and Executive Director for planning an official visit to China, 1984-1985.
- Member of the ASME Delegation to China, May, 1985.

Project Director of a proposed ASME-NBS Software Research project, DATAX, for ASME Committee on Software Research, 1984-1986.

## NATIONAL ENGINEERING LABORATORY

### CENTER FOR BUILDING TECHNOLOGY (CBT)

Conferences:

1987 ASME Summer Annual Meeting

- R. Wright, Director, Center for Building Technology - Briefed the ASME Council on Engineering and the Council on Codes and Standards on potential cooperative work on machine representations of standards.

Ninth Solar Energy Division Conference, 1987

- A.H. Fanney and B. Mahajan - Session Chairmen.
- Mahajan, B.M., "Flow Coefficients for Interzonal Natural Convection for Various Apertures."
- Liu, S.T., "Experimental and Analytical Investigation of Solar Radiation on Interior Surfaces of a Sunspace."

Eighth Solar Energy Division Conference, 1986

- A.H. Fanney and B. Mahajan - Session Chairmen.
- Fanney, A.H. and Dougherty, B.P., "A Self-Heated Thermistor Flowmeter for Flow Measurements in a Thermosyphon Solar Hot Water System."
- McCabe, M.E., "Diurnal Effectiveness of Phase-Change Energy Storage Cylinders."
- Mahajan, B.M., "Inter-room Air Flow by Natural Convection via a Doorway Opening."

AIAA/ASME Thermophysics and Heat Transfer Conference, 1986

- McCabe, M.E., "Periodic Heat Conduction in Energy Storage Cylinders with Change of Phase."

106th Winter Annual Meeting, 1985

- M.E. McCabe - Session Vice-Chairman.
- Mahajan, B.M., "Interzonal Natural Convection for Various Aperture Configurations."
- Greenberg, J., "Plan for the Development of Test Procedures for Differential Temperature Controllers Used in Solar Energy Systems."

105th Winter Annual Meeting, 1984

- M.E. McCabe - Session Organizer and Chairman.
- Mahajan, B.M., Liu, S.T., and Reed, K.A., "Performances of Different Passive Solar Systems at the NBS Test Facility."
- Thomas, W.C. and Reed, K.A., "Effect of Infrared Irradiance on Collector Thermal Performance."
- Waksman, D., Thomas, W.C., "Conclusions and Recommendations for the Testing of Flat-Plate Solar Collector Thermal Performance and Durability."



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Sixth Solar Energy Division Conference, 1984

- Fanney, A.H., "An Experimental Technique for Testing Thermosyphon Solar Domestic Hot Water Systems."

Fifth Solar Energy Division Conference 1983

- A.H. Fanney - Session Chairman.
- Mahajan, B.M. and Liu, S.T., "Initial Results from NBS Passive Solar Energy Test Facility."
- Klein, S.A. and Fanney, A.H., "A Rating Procedure for Solar Domestic Hot Water Systems."
- Fanney, A.H. and Klein, S.A., "Performance of Solar Domestic Hot Water Systems at the National Bureau of Standards - Measurements and Predictions."
- Thomas, W.C., Dawson, III, A.G., Waksman, D., "Testing Solar Collector Materials Durability by Integrated Day-Long Stagnation Temperature Measurements."

104th Winter Annual Meeting, 1983

- McCabe, M.E., "Solar Energy Absorption by Vertical Cylindrical Tube Absorbers in Sunspace Enclosures."

ASME Committee Memberships:

ASME Solar Energy Executive Committee

- A.H. Fanney - Vice-Chairman 1988-1990

Solar Testing and Measurement Committee, Solar Energy Division

- A.H. Fanney - Chairman, 1984-1987
- B. Mahajan
- M.E. McCabe

Other ASME Publications:

Journal of Solar Energy Engineering

- Fanney, A.H. and Dougherty, B.P., "A Self-Heated Thermistor Flowmeter for Flow Measurements in a Thermosyphon Solar Hot Water System," 1987.
- Mahajan, B.M., "Measurement of Air Velocity Components of Natural Convective Interzonal Airflow," 1987.
- Waksman, D., Thomas, W.C., "The NBS Solar Collector Reliability/Durability Test Program: Summary of Results and Recommendations for Collector Testing," 1986.
- Thomas, W.C., Dawson, III, A.G., Waksman, D., "Use of Integrated Day-Long Stagnation Temperature for Measuring Changes in Solar Collector Materials Properties," 1985.
- Fanney, A.H., "An Experimental Technique for Testing Thermosyphon Solar Domestic Hot Water Systems," 1984.
- Klein, S.A. and Fanney, A.H., "A Rating Procedure for Solar Domestic Hot Water Systems," 1983.
- Fanney, A.H. and Klein, S.A., "Performance of Solar Domestic Hot Water Systems at the National Bureau of Standards - Measurements and Predictions," 1983.

o Dawson, III, A.G., Thomas, W.C., and Waksman, D., "Solar Collector Durability Evaluation by Stagnation Temperature Measurements," 1983.

NATIONAL ENGINEERING LABORATORY

CENTER FOR FIRE RESEARCH (CFR)

Conferences:

109th ASME Winter Annual Meeting, 1988
- o J.G. Quintiere - Panelist, "Panel on Program Emphasis in Heat Transfer Research at Federal Funding Agencies."

108th ASME Winter Annual Meeting, 1987
- o V. Motevalli, C.H. Marks, (NIST Guestworkers from the University of Maryland), B. McCaffrey (CRF), "Measurement of Velocity and Temperature Profiles in Low-Speed Turbulent, Non-Isothermal Flows."

ASME-JSME Thermal Engineering Joint Conference, March 22-27, 1987, Honolulu, Hawaii
- o Len Cooper (CFR), along with B. Farouk (Drexel University) - Organized the Heat and Mass Transfer in Compartment Fires Sessions.
- o Pitts, W.M., "The Effects of Global Density and Reynolds Number Variations on Mixing in Turbulent Axisymmetric Jets - Implication for Turbulent Diffusion Flames."
- o DiMarzo, M., Evans, D.D., and Trehan, A.K., "The Cooling Effect of a Single Evaporating Droplet on a Hot Semi-Infinite Metal Body."
- o Finlayson, E., Aung, W. and Kashiwagi, T., "Interaction of Radiation and Conduction in Polymeric Materials Exposed to External Thermal Radiation."
- o Morehart, J. and Evans, D.D., "Investigation of the Effects of a Stratified Two-Layer Environment on Fire Plume Temperatures."
- o Woodhouse, A., Marks, C.H. and Cooper, L.Y., "An Experimental Study of the Transient Thermal Response of Unconfined Ceilings Above Fire Plumes."

24th ASME/AIChE National Heat Transfer Conference, 1987
- o DiMarzo, M. and Evans, D.D., "Evaporation of a Water Droplet Deposited on a Hot High Thermal Conductivity Solid Surface."
- o Cooper, L.Y., "Heat Transfer in Compartment Fires Near Regions of Ceiling Jet-Impingement."
- o Saito, K., Williams, F.A., Wichman, S., Quintiere, J., "Upward Turbulent Flame Spread on Wood Under External Radiation."

23rd ASME/AIChE National Heat Transfer Conference, 1985
- o Cooper, L. and Woodhouse, A., "The Buoyant Plume-Driven Adiabatic Ceiling Temperature Revisited."

22nd ASME/AIChE National Heat Transfer Conference, 1984
- o L. Cooper - Paper presentations.

21st ASME/AIChE National Heat Transfer Conference, 1983

- J. Quintiere - Organized the fire dynamics and fire heat transfer sessions.
- L. Cooper, D. Evans, and T. Kashiwagi - Presented papers at these sessions published by ASME in a single volume which serves as an introduction to fire science, fire dynamics, and heat transfer (edited by J. Quintiere).
- Cooper, L.Y., "On the Significance of a Wall Effect in Enclosures with Growing Fires."
- Evans, D.D., "Plume Flow in a Two-Layer Environment."

1983 ASME Winter Annual Meeting - Symposium on Modeling of Environmental Flow Systems

- Cooper, L.Y., "A Buoyant Source in the Lower of Two, Homogeneous Stably Stratified Layers."

ASME Committee Memberships:

K-11 Committee on Heat Transfer in Fire and Combustion Systems

- J. Quintiere - Chairman of the K-11 Committee (1986-1988)
- Len Cooper
- Various NIST grantees
- The founder of K-11 and recent past Chairman of the Heat Transfer Division, Prof. John R. Lloyd, is currently a member of the NAS-NAE-NRC Board of Assessment of NIST Programs for CFR which serves to advise and evaluate the Center's program.

Other ASME Publications:

- Cooper, L.Y., "Heat Transfer in Compartment Fives Near Regions of Ceiling-Jet Impingement on a Wall," accepted for publication in Journal of Heat Transfer.
- Cooper, L.Y. and Stroup, D.W., "Thermal Response of Unconfined Ceilings Above Growing Fires and the Importance of Convective Heat Transfer," Journal of Heat Transfer, 1987.
- Cooper, L.Y. and Kennedy, L.A., "Heat and Mass Transfer Research Topics in Fire and Controlled Combustion Systems," Mechanical Engineering, 1986.
- Cooper, L.Y. and Woodhouse, A., "A Buoyant Plume-Driven Adiabatic Ceiling Temperature Revisited," Journal of Heat Transfer, 1986.

## NATIONAL ENGINEERING LABORATORY

### CENTER FOR ELECTRONICS AND ELECTRICAL ENGINEERING (CEEE)

Conferences:

1987 ASME Winter Annual Meeting

- Frank F. Oettinger - Lead speaker on the "Panel on Standardization in Thermal Resistance for Microelectronics" jointly sponsored by the Electrical and Electronics Packaging Division and the Heat Transfer Division's K-16 Committee.

ASME Committee Memberships and Contributions to Standards:

K-16 Committee on Heat Transfer in Electronic Equipment

- Frank Oettinger facilitated a working relationship with the K-16 Subcommittee on Measurement Standards and Procedures and related Semiconductor Equipment and Materials International (SEMI) standardization activities in ceramic and plastic IC package thermal test methods.

- This interaction has resulted in the publication of SEMI Test Method G43-87, "Still- and Forced-Air Junction-to-Ambient Thermal Resistance Measurements of IC packages," in the 1987 Book of SEMI Standards. This is the first document of its kind in which a standardized approach has been agreed upon by the semiconductor industry using a wind-tunnel for forced-air convection testing of microelectronic devices.

- As General Chairman of the 1988 IEEE Semiconductor Thermal and Temperature Measurement Symposium (SEMI-THERM), Oettinger discussed with Dr. Richard Wirtz, Chairman of ASME K-16 Committee, the possibility of K-16 being a co-sponsor or cooperating society with IEEE. No decision has as yet been made.

NATIONAL ENGINEERING LABORATORY

CENTER FOR CHEMICAL ENGINEERING (CCE)

Conferences:

25th ASME/AIChE National Heat Transfer Conference, 1988
- o H.G. Semerjian - Session Chairman on Combustion Fundamentals.

AIAA/ASME/SAE/ASEE 24th Joint Propulsion Conference, Boston, MA, July 11-12, 1988
- o C. Presser - Session Chairman on Sprays/Injectors.
- o Presser, C., Gupta, A.K., and Semerjian, H.G., "Dynamics of Pressure-Jet and Air-Assist Nozzle Sprays: Aerodynamic Effects."

1988 10th ASME International Symposium on Thermophysical Properties, NBS, Gaithersburg, MD, June 20-24, 1988
- o Berg, R.F., "Low Frequency Critical Viscosity of Four Binary Liquids."
- o Bruno, T.J., "Supercritical Fluid Chromatograph for Physicochemical Studies: Binary Diffusion Coefficients."
- o Cezairliyan, A. and Sengers, J.V. - Organizers and Chairmen.
- o Clark, E.J., "Crystallization and Fibril Formation in Polymers."
- o Diller, D.E., "Torsional Piezoelectric Crystal Viscometer for Compressed Gases and Liquids."
- o Ely, J.F., and Magee, J.W., "PVT Relationships in a Carbon Dioxide Rich Mixture with Ethane."
- o Fox, J.R., "A Field-Space Conformal Solution Method."
- o Friend, D.G., "The Viscosity Surface for Mixtures of Methane and Ethane."
- o Gallagher, J.S., "The Modelling of the Thermodynamic Properties of Sodium Chloride in Steam Through Extended Corresponding States."
- o Goodwin, A.R.H., "Measurements of the Speed of Sound in Argon, Methane, a Natural Gas and Air at High Pressures using a Spherical Resonator."
- o Hanley, H.J.M., "Prediction of Shear Viscosity and Non-Newtonian Behavior in the Soft Sphere Liquid."
- o Haynes, W.M., "Automated Magnetic Suspension Densimeter with Optical Sensing."
- o Huber, M.L., "Extension of an Improved One-Fluid Conformal Solution Theory to Real Fluid Mixtures with Large Size Differences."
- o Jacobsen, R.T., Clarke, W.P., and Penoncello, S.G., and McCarty, R.D., "A Revised Interium Thermodynamic Property Formulation for Air."
- o Miller, A.P., "Thermal Expansion of Tungsten in the Range 1500-3600 K by a Transient Interferometric Technique."
- o Moldover, M.R., "The Tension and Thickness of Interfaces in the Critical Region of Fluids."

- Moldover, M.R., "Measurement of the Universal Gas Constant R with a Spherical Acoustic Resonator."
- Morrison, G., "Phase Transitions in the Liquid Phases of Monomolecular Films."
- Morrison, G., "New Methods for Locating Phase Boundards."
- Morrison, G., "Critical Points in Electrolytes: What are the Issues? What Experiments Should be Done?"
- Nieto de Castro, C.A., "The Viscosity of Liquid Toluene Under Pressure."
- Nieto de Castro, C.A., "The Thermal Conductivity of Refrigerant R142b."
- Outcalt, S.L., "Direct Fugacity Measurements on Hydrogen Mixtures."
- Rainwater, J.C., "Asymptotic Expansions for Dew-Bubble Curves Near the Critical Locus."
- Roder, H.M., and Nieto de Castro, C.A., "Thermal Conductivity, Thermal Diffusivity and Heat Capacity of Nitrogen from Transient Hot-Wire Measurements."
- Schmidt, J.W., "Structure of the Liquid-Liquid Interface Near $T_c$."
- Storvick, T.S., "A Field-Space Conformal Solution Method: Binary Vapor-Liquid Phase Behavior."
- Van Poolen, L.J., "Representation of Binary Mixture Liquid-Vapor Equilibria by Means of Critical Isochores."
- Van Poolen, L.J., "Thermodynamic Properties of Air on the Dew and Bubble Lines."

1987 ASME Winter Meeting, Anaheim, CA

- Morrison, G., "Application of the Carnahan-Starling-DeSantis Equation of State to Mixtures of Refrigerants."

1987 ASME Winter Annual Meeting, Boston, MA, Nov. 3-4, 1988

- Mattingly, G.E. - Organized and Chaired Session on Fluid Flow Measurement Uncertainty (I and II).

24th ASME/AIChE National Heat Transfer Conference, 1987

- Jones, M.C., "Retrograde Condensation of Carbon Dioxide--N-Decane Mixtures on Horizontal Cylinders."

AIAA/SAE/ASME 23rd Joint Propulsion Conference, San Diego, CA, July 1987.

- Presser, C., Gupta, A.K., Semerjian, H.G., "Nozzle Design Effects on Droplet Size and Transport in Fuel Sprays."

ASME, MFFCC Meetings, New York, NY, May 1987.

- G.E. Mattingly - Described NBS' Round Robin Flowmeter Testing.

2nd ASME/JSME Thermal Engineering Joint Conference, Honolulu, Hawaii, March 1987.

- H.G. Semerjian - Organized three sessions on Combustion Fundamentals and chaired one session.

International Symposium on Fluid Flow Measurement, Washington, DC, Nov. 1986; jointly sponsored by AGA, API, ASME, GPA, GRI and NBS.
- N.A. Olien - Member of organizing committee.

23rd ASME/AIChE National Heat Transfer Conference, 1985
- Santoro, R., Yeh, T., and Semerjian, H., "The Transport and Growth of Soot Particles in Laminar Diffusion Flames."

June 1985 9th ASME Symposium on Thermophysical Properties, NBS, Boulder, CO.
- H. Hanley - Chairman.

ASME Committee Memberships:

ASME Research Committee on the Properties of Steam
- J.M.H.L. Sengers
- J.V. Sengers
- J.S. Gallagher

ASME K-7 Thermophysical Properties of the Heat Transfer Division
- A. Cezairliyan
- H. Hanley
- J.V. Sengers
- J.F. Ely

George E. Mattingly's memberships include:
- ASME (Main) Committee on the Measurement of Fluid Flow in Closed Conduits
- ASME SC-2, Pressure Differential Devices
- ASME SC-6, Glossary of Terms for Flow Measurements (Past Chairman)
- ASME SC-14, Measurement of Fluid Flow Using Gravimetric and Volumetric Techniques (Chairman)
- ASME SC-15, Installation Effects on Orifices
- ASME SC-16, Vortex Shedding Type Flowmeters (Past Chairman)
- ASME (Main) Research Committee on Fluid Meters
- ASME SC-11, Test Methods and Calculation Procedures (Chairman)

ASME K-6 Committee on Heat Transfer in Energy Systems
- C. Presser

ASME K-11 Committee on Heat Transfer in Fires and Combustion Systems
- H.G. Semerjian

ASME PTC 19.18, Committee on Humidity Determination
- S. Hasegawa

Special Activities:

NIST and ASME work together in the North American Fluid Flow Measurement Council. Other members include the American Gas Association, Canadian Gas Association, Pacific Energy Association, Gas Processors Association, American Petroleum Institute, Gas Research Institute, Institute of Gas Technology, and Instrument Society of America.

## NATIONAL MEASUREMENT LABORATORY

### STANDARD REFERENCE DATA (SRD)

ASME Committee Memberships and Contributions to Standards:

ASME Research and Technology Committee on Water and Steam in Thermal Systems

- Dr. Howard J. White, Jr. - This Committee serves as the U.S. National Committee to the International Association for the Properties of Steam (IAPS), for which Dr. White is the Executive Secretary. The next Committee meeting will be held at NIST on May 8,9, 1989. The Research Committee is also represented at the annual meeting of IAPS -- this meeting was held in August 1988 in Vancouver, B.C. The next meeting will be held during the 11th International Conference on the Properties of Steam in Prague, Czechoslovakia in September 1989. In its own right and through IAPS, there are extensive interactions between the activities of the Research Committee and those of the NIST Office of Standard Reference Data.

Special Activities:

Dr. John Rumble is on the Board of Trustees of ACTIS, Inc., a new corporation established to build tribology information systems. ASME and NIST worked together on this effort.

## NATIONAL MEASUREMENT LABORATORY

### CENTER FOR CHEMICAL PHYSICS (CCP)

Conferences:

13th National Waste Processing Conference, Philadelphia, PA, May 1988
- Buckley, T.J., and Domalski, E.S., "Evaluation of Data on Higher Heating Values and Elemental Analysis of Refuse-Derived Fuels."
- Churney, K., Ledford, Jr., A.E., Buckley, T.J., and Domalski, E.S., "Chlorine Mass Balance in the Combustion of Refuse-Derived Fuel."

12th National Waste Processing Conference, June 1986
- Domalski, E., "The Chlorine Content of municipal Solid Waste from Baltimore County, MD and Brooklyn, NY."
- Churney, K., "Assessing the Credibility of the Calorific Value of Municipal Solid Waste."

ASME Committee Memberships:

Research Committee on Industrial and Municipal Wastes
- Dr. Eugene Domalski

ASME Dioxin Committee
- K. C. Churney

Research Committee on Properties of Steam
- D. Neumann

Other ASME Publications:

- Domalski, E.S., and Jobe, Jr., T.L., "Thermodynamic Data for Biomass Materials and Waste Components," 1987, (ASME/NBS/SERI publication).

## INSTITUTE FOR MATERIALS SCIENCE AND ENGINEERING

Conferences:

ASME/JSME Pressure Vessel and Piping Conference, July 1989
- Tom Siewert - Session Organizer on Real-Time Radiography and Paper Presentation.

ASME/STLE Joint Conference, October 1988
- S.M. Hsu - Session Organizer and Speaker.
- R.S. Gates - Paper presentation.
- J. Perez - Paper presentation.

Pressure Vessel and Piping Conference, June 1988
- Sumio Yukawa - Co-Author of paper on ASME Code Toughness Requirements.

ASME Manufacturing Science and Technology Program, Manufacturing International Conference - April 1988
- Bruce Christ - Submitted invited paper on plastic materials in car and truck construction.

ASME Offshore Mechanics and Arctic Engineering Conference, 1988
- Harry I. McHenry - Session Organizer, Paper presentation.

ASME Offshore Mechanics and Arctic Engineering Conference, 1987
- Harry I. McHenry - Paper presentation.

Winter Annual Meeting, December 1987
- Sumio Yukawa - Panel Session Organizer on Databases.

Fifth National Congress on Pressure Vessels and Piping Technology, 1987
- Harry I. McHenry - Paper presentation.

ASME Tribology Workshop, 1985
- Jointly sponsored by NBS, DoE, and ASME.
- Bill Ruff and John Rumble - Participants.

ASME Committee Memberships:

Materials and Structures Group
- Sumio Yukawa - Immediate Past Vice-President

Council on Engineering Database Committee
- Sumio Yukawa

Boiler and Pressure Vessel Code Committee
- Sumio Yukawa participation includes:
  - Subgroup on Toughness, SC on Properties
  - Task Group on Very High Temperature Design, SC on Design
  - Subgroup on Evaluation Standards, SC XI
  - Working Group on Materials, Subgroup on NUPACK, SC II

ASME/NIST Interaction Committee
- Sumio Yukawa - Corresponding Member

Tribology Division
- A.W. Ruff
- S.M. Hsu
- S. Jahanmir

Research Committee on Tribology
- S. Jahanmir - Chairman
- A.W. Ruff
- M.B. Peterson
- S.M. Hsu

ASME Technical Economics Program - Materials Committee
- Bruce Christ

ASME Editor:

Journal of Applied Mechanics
- R.D. Kriz - Reviewer.

Special Activities:

Bill Ruff - NIST liaison with ASME Washington office on Tribology data.

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Gail K. Ehrlich

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WASHINGTON, D.C. 20234

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9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This report highlights examples of interactions between the National Institute of Standards and Technology (NIST) and the American Society of Mechanical Engineers (ASME) over the past several years. It is meant to be representative, not all-inclusive. The interactions are organized by discipline in the following categories: Conferences, Committee memberships and contribution to standards, Editors, Publications, Honors and awards, and Special activities. The report illustrates many activities which are designed to disseminate NIST's most recent technical advances and to learn of the technical challenges facing engineers in industry.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

ASME; computers; heat transfer; mechanical engineering; pressure vessel piping; robotics; solar energy; standards; technology transfer; tribology

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Mr. WALGREN. Thank you, Mr. Ling. I appreciate that very much.

I would turn to Dr. Russell Drew, President of the Institute of Electrical and Electronic Engineers.

Welcome to the Committee, Dr. Drew.

## STATEMENT OF DR. RUSSELL C. DREW, PRESIDENT, INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEERS

Dr. DREW. Thank you very much, Congressman Walgren. It is a great pleasure to be back and have an opportunity to testify before this committee on behalf of the U.S. members of the IEEE and particularly our engineering R&D committee, which has had a principal role in developing the substance of my testimony before you today.

First of all, let me say I have to strongly second the remarks of my colleague, Mr. Ling, and the opening remarks, Mr. Chairman, that you provided about the continuing state of the NIST, and formerly NBS, budget over the years. We have shared this view with you in previous years. It is a mystery to me why this message has not gotten back to the people who are responsible for submitting these proposals to the Congress each year.

We certainly would second—in fact, strongly support—any efforts that you may undertake this year to turn this around in a rather substantial and significant way.

I come to you actually with a rather modest recommendation for rather minor increases above those which were proposed, but in the larger sense I think there is a strong point to be made here, and it is a point which it seems to me flows from the efforts of the Congress, this committee particularly, in adding the very important technology provisions to the Omnibus Trade and Competitiveness Act.

It seems to me that we are now moving in a direction where the Department of Commerce is recognized, is being recognized, as a lead agency in what I would call the commercialization and application of technology. And in that sense, at the end of my testimony I am going to cover some broader issues about the organization to deal with these aspects of technology which we hope you will accept, which tends to focus on this broader role rather than just the current year's budget for NIST.

But let me talk about NIST. In the previous several years, we have tried to emphasize a few key areas and we would like to reemphasize those areas with you today.

First of all, let me talk about computers. We have the National Computer Systems Laboratory [NCSL] now, with an initiative having to deal with computer security, which we endorsed last year and which is being proposed to receive $3.5 million of funding. And we support that. We very strongly support that.

But the larger framework of the NCSL has not received the additional companion funding. And we are recommending that approximately $3 million be added to the NCSL to extend their work in very vital other areas, particularly in dealing with the inter-operability of computer systems. An important direction in computer

system usage in the U.S. today is the linkage of computer systems via large- and small-scale networks.

We are still in the situation where we have got the equivalent of Chinese- and Japanese- and English- and Russian-speaking computers, all trying to communicate with each other. Work in bringing about better ability to link these systems is an important role for the NIST and we believe it needs to be more adequately funded.

Light wave technology was mentioned. I will not repeat the excellent specifics of my colleague, Mr. Ling. We recommended last year that it be increased by about $5 million. It received a trivial increase. We would call it trivial in comparison with need. This year's increase in funding needs further supplemental funds, and we are recommending $2 million there.

Microwave standards is an initiative which the Bureau—which NIST has undertaken. We have been working with them via the MTT society within IEEE to define that. We strongly support it. But again, underfunded. And we are asking for a very modest $2 million increase in microwave standards development.

Finally, the ability of NIST to move aggressively in all of these areas will depend upon the quality of the people that they have at the Bureau and the quality of the new people that they can attract. The rather innovative personnel compensation system which they are allowed to employ has been hampered by the ceiling that has been placed on overall salaries.

They have had to eat, if you will, any increases within their total budget, and we believe that all of the programs at NIST will benefit from some flexibility in the personnel salary ability of the director of NIST. And we believe $2 million to $3 million would be required to accomplish that.

Finally, let me close by pointing out that we believe that this move to begin to codify institutional support bases for technology in the Department of Commerce should be further extended, and we are suggesting that you might in fact think about renaming the department as the Department of Commerce and Technology, and very specifically, picking up on some of the continuing proposals from one of your esteemed colleagues on the committee, that we should think about—and we have some specific suggestions—a national technology agency within the department to begin to start to focus these efforts.

We should emphasize, and we do in the testimony, that it should not detract from nor somehow or other be shoehorned into NIST at the expense of existing standards roles of NIST. And unfortunately, that has been the record in the past, and I think we just need a more vigorous level of funding support and management from the department to accomplish this.

Well, I appreciate this time, and I will be prepared to answer any questions you may have.

[The prepared statement of Dr. Drew follows:]

IEEE UNITED STATES ACTIVITIES

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STATEMENT OF

DR. RUSSELL C. DREW

ON BEHALF OF THE

IEEE-USA ENGINEERING R&D COMMITTEE

ON THE FY 1990 BUDGET FOR

THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

BEFORE THE

HOUSE SCIENCE, SPCAE AND TECHNOLOGY COMMITTEE

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

MARCH 23, 1989

**1989 IEEE NIST TESTIMONY FOR RUSS DREW** **23 March 1989**

**EXECUTIVE SUMMARY**

- Standard who we are, why we care
- Importance of the Bureau
  - new position to be stated at end of testimony
  - budget decreased, underfunding is worse; now NIST has a larger mission too!
  - example: Broadband ISDN standards
  - New personnel system should be funded for raises
- As in past, NCSL (old ICST) is inadequately funded- counter to competitiveness needs
  - funding for Computer Security program good but didn't grow enough
  - Short-sighted not to fund networking in ICST- losing economic benefits
- Basic measurements EE area underfunded, despite good efforts by NIST
  - Superconductors and lightwave measurement initiatives are good
  - NIST has started microwave standards initiative- this should be funded!
- Our recently developed position on govt. organization for technology development:
  - Technology equal to science and at cabinet level
  - Stronger OSTP, Science advisor ranking with National Security Advisor
  - Better funding for NIST, **separate commercial technology agency like DARPA**

**STATEMENT OF DR. RUSSELL C. DREW**
**ON BEHALF OF THE IEEE-USA ENGINEERING R&D COMMITTEE**
**ON THE FY 1990 BUDGET FOR**
**THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY**
**before the**
**House Science, Space and Technology Committee**
**Subcommittee on Science, Research, and Technology**

**March 23, 1989**

Technology and its growth and application are particular interests of the IEEE. We are the largest technical professional society in the world, with almost 240,000 members in the United States who are engaged in advancing the frontiers of knowledge and supporting the public with a broad and growing range of electrotechnologies. As you would expect, we have a special interest in U.S. government programs which support the advance of technology, so vital to the nation's competitive position. We are therefore eager to address the elements of the proposed National Institute of Standards and Technology (NIST) budget that affect electrical and computer engineering science and technology, and to provide our perspective on the role of the Department of Commerce in fostering development of technology for the nation.

There can be no doubt that NIST fills an essential role in supporting the Nation's science and technology base. As the unbiased arbiter of the many issues which the technical community faces relating to measurement, it performs a key function of government for the country. Moreover, this is an ever-growing role, as the variety and complexity of measurement expands with the growing wave of modern technological society. A sound national and international system of measurement is vital to research and development, productivity growth, assurance of quality, and a healthy posture for international trade. The basic and applied research performed by NIST in support of measurement is, in a word, vital. Furthermore there are other vital national roles in technology which are not being performed adequately. We will address this matter further at the end of our testimony.

Unfortunately the NIST budget has not been adequate in recent years to deal with its vital mission. As the Bureau of Standards it was historically underfunded to execute its basic role, and burdened with additional tasks inspired by the high technical quality of its people and facilities. Each new project brought a small increment of funds, with a promise of outyear increases; in reality, the increases often fail to materialize, and the Bureau was left with an expanded mission and insufficient resources. Two years ago we called for steps to increase the overall NBS budget to $200 million over three to five years. Last year's increase to $159 million was a welcome step in that direction, although we were unhappy that new initiatives were funded at the expense of the basic mission, and the fact that the 1988 increase was accompanied by the transformation of NBS to NIST, including a major expansion in mission, which again diminished funding available to support the critical standards role. We estimate that an appropriated budget of at least $250 million per year will be necessary to include the new mission. This year's decrease to $156 million, with essentially zero allowance for inflation and another $15 million in new initiatives, is another step toward the brink of disaster. There can be little doubt why the international competitive position of the United States continues to decline when the Federal government does not adequately support its own standards role which, under the law, can belong to no other organization. This synergistic role is absolutely vital, although it will cost only a tiny fraction of the amount invested by industry, and a tiny fraction of the overall Federal budget.

A case in point is the Broadband Integrated Services Data Network (BISDN) standard, which deals with the leading edge of progress in data communications. Since the breakup of the Bell System, NIST has been the only organization which legally can coordinate this type of development. Because no resources are available for this activity, development of nationwide service is lagging. This is a "double whammy' for the U.S., in that it both cripples our ability to progress in computer networking, a key enabler of productivity gains, and also virtually guarantees that when BISDN eventually becomes available we will be buying our equipment from foreign sources!

Another extremely shortsighted position is the policy imposed on NIST's new alternative personnel system restricting salaries to zero average real growth. We see the NIST personnel system as one of the few bright spots in an otherwise gloomy personnel picture at the Federal laboratories. There is a real opportunity for the NIST system to lead the way to a time when the Federal government can once again attract sufficient numbers of high-quality scientists and engineers to staff its facilities. Yet NIST is being restrained from exercising much of the flexibility allowed under the law establishing the new system. In effect, those who would restrain salaries at NIST in this way are saying that, on the average, Federal salaries are sufficient to attract and keep good technical people. Anyone who has examined the situation knows that this not the case!

## COMPUTER SCIENCE AND TECHNOLOGY PROGRAMS

Year after year we point out the criticality of the computer industry in the U.S., the competitive challenges it faces from abroad, and the need for a healthy standards program to support it. Again this year we observe that funding for the National Computer Systems Laboratory (NCSL) is inadequate. As in the past, we support increased funding for the Computer Security program, and believe the additional $3.5 million requested should be an appropriate increase to support a healthy program in that area. However, before NIST received the Computer Security mission we called for an increase in base funding to $15 million; with continued expansion of computer and information technology, the $10 million provided for Fiscal Year 1990, one-fourth of which would support existing efforts in Computer Security, is simply not sufficient.

A particularly critical area is computer networking and data communications. NIST received new missions in telecommunications in 1986, but has yet to receive additional

funding. The Broadband ISDN standards are only one part of this problem; tremendous opportunities lie in this area, both for saving the government money and for enabling increases in U.S. competitiveness. In this market hundreds of billions of dollars are spent annually, yet the standards process is dominated by the Europeans because NIST is not funded to take an active role. The importance of these standards in creating an adequate U.S. industrial base is so great that the Department of Defense has found it necessary to fund the NCSL to work with the new (European-developed) OSI standards for its defense data networks. The potential benefits of such standards in reduced cost, both to the government and to the country, as a whole far outweigh the cost of a highly-leveraged program at the NIST. Even more important, the U.S. economy would obtain tremendous advantage if this country were a major world supplier of compatible networking systems.

## MEASUREMENT SCIENCE AND PRECISION MEASUREMENT STANDARDS

This is another area where, year after year, we have voiced our concern with the failure of the Federal government and industry to keep pace with the growing need for precision measurements of assured accuracy and authenticity. Such measurements are needed to retain a competitive role in a marketplace where more than $160 billion per year is spent on measurements in the U.S. alone, and precision measurements are essential to introduction of technology as a force multiplier in our military. We urge the Congress to act now to end neglect of the central role of NIST, which is research, development and dissemination of adequately precise and accurate measurement, measurement standards, and methods of measurement.

We are pleased to note that among the new initiatives in the National Engineering Laboratory, Lightwave Measurement and High Temperature Superconductors have a prominent place. These worthy efforts will support technology growth critical in the electrical, electronics and computer industries; our only concern is that they are probably

not adequate (last year we called for a funding level of $8.5 million in the Lightwave Measurement area alone).

We have also been pleased to learn that NIST is responding to our previous calls for new efforts in millimeterwave and microwave standards. This effort, which we expect to appear in the Fiscal Year 1991 budget, is a critical one. The situation has become so serious that one of IEEE's technical societies has created a committee known as Promote National Microwave Standards (PNMS) to focus attention on what we perceive as a growing crisis. Their report contained statements such as:

> "NBS efforts in microwave and millimeterwave calibration standards have declined by a factor of two over the past 15 years while the U.S. microwave and millimeterwave industry has doubled"

and that:

> "... it is the conclusion of the PNMS Committee that the present status must be changed dramatically. Otherwise the NBS capabilities in microwave calibration standards will continue to decline relative to the needs of U.S. government and industry and fall behind foreign competition."

The PNMS report cites needs in excess of $38 million over a five year period to attend to some 75 of the most serious deficiencies. We urge that the Congress provide additional funding of at least $2 million in Fiscal Year 1990 to support the immediate start of this urgently needed microwave standards initiative.

## GOVERNMENT ORGANIZATION FOR COMMERCIAL TECHNOLOGY DEVELOPMENT

Last year at this time we presented a new position, developed by our Engineering Research and Development Committee, which called for increased Federal government emphasis on commercial technology in order to remedy the nation's increasingly critical position with regard to technological competitiveness. We are pleased to note that much

of what we recommended was considered in legislation which created NIST and instituted an Undersecretary of Commerce for Technology. For our part, the efforts of several of our committees have been focused into a new IEEE-USA Technology Activities Council position, which is provided with this testimony. In this position we call even more strongly for focused Federal efforts in technology: We strongly support the President's announced intention to strengthen the role of his Science Advisor and the Office of Science and Technology Policy, and we urge further Congressional action to affirm the role of the Department of Commerce to provide a cabinet-level voice for technology. Beyond adequate support of NIST, new government capabilities for action in the arena of commercial technology are needed.

Our considered conclusion is that an entirely new National Technology Agency (NTA) is needed, to support advanced technology research and development projects focused on the commercial marketplace. Lack of such an agency in the U.S. is giving an advantage to our international competitors. We view this agency as a civilian version of the Defense Advanced Research Projects Agency. Its functions would include those presently filled for Science by the National Science Foundation, but with a focus on *technology* rather than *science*. We recognize that the Trade Act of 1988 created the Advanced Technology Program in NIST, but did not fund it. We would emphasize that it is important for the NTA to be distinctly separate from NIST (although closely affiliated), in order to avoid contention for resources. We strongly urge the Congress to create such an agency as soon as possible.

The IEEE's U.S. members stand ready to help in keeping this country's position of leadership in technology. We are pleased to have been able to share our views on the National Institute of Standards and Technology and the importance of a new National Technology Agency with you, and would be happy to assist in any other way we can.

# ENTITY POSITION STATEMENT

FEDERAL GOVERNMENT ORGANIZATION FOR TECHNOLOGICAL COMPETITIVENESS

The Institute of Electrical and Electronics Engineers, Inc.

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This statement updates and supersedes the IEEE-USA position National Technology Foundation of June 1983, and is issued as a companion to the IEEE-USA positions Industrial Competitiveness of May 1986 and U.S. Engineering Research and Development of November 1986. The first of these establishes the critical role of technology in national competitiveness. The second differentiates engineering research, which is the source of technology development, from scientific research. We support scientific research strongly; however, science is not addressed here. Technology is the critical issue.

**RECOMMENDATIONS:** To regain the United States' position as a strong world leader in technology, and to strengthen the U.S. position in technological competitiveness internationally, the IEEE-USA recommends that:

- The Executive Branch provide a voice for technology at the cabinet level. The Department of Commerce appears to be the logical candidate for this responsibility;
- The Congress provide adequate funding for the standards mission of the National Institute of Standards and Technology, give the Department of Commerce further responsibilities by establishing a National Technology Agency within the Department, and provide adequate resources to discharge the augmented responsibilities; and
- The role of the Office of Science and Technology Policy be strengthened, and the President's Science Advisor be elevated to have a voice and influence equal to that of the National Security Advisor.

Technology Activities Council — March 20, 1989

Approving Entity — Date

DISCUSSION:

**A Cabinet-Level Voice for Technology.** Although technological leadership must rest primarily with the private sector, government policies and actions have a strong influence on either promoting or deterring it. The United States needs a rational, integrated national policy on technology, designed to achieve and maintain technological leadership to enhance U.S. industrial competitiveness in global markets. Our international competitors are drawing ahead of us, in part because their governments promote technology development more effectively. The U.S. needs effective policies which embrace technology research and development, trade, education and training, and the economics of capital formation. Government funding of high-risk research and development, including work performed in Federal laboratories, must be coordinated to complement investments in the private sector. Responsibility for promoting technology currently is distributed among too many different agencies to be effective in improving competitiveness and enhancing our trading position. The relevant agencies are simply too fragmented and uncoordinated to establish and implement such a policy.

Competitiveness requires not only development of leading-edge technologies, but sucessful commercialization, which implies an environment in which products can successfully compete in international trade. Thus, policies for technology and trade must be coordinated closely. Further, since industrial competitiveness and our trade balance are such critical issues in the national agenda, and since it is now understood that industrial competitiveness depends strongly on deployable, new technologies, these issues need to be managed at top policy levels to get the attention that U.S. national trade interests require.

**Augmented Technology Resources in the Department of Commerce.** The recent establishment of the National Institute of Standards and Technology (NIST) and an Undersecretary for Technology within the Department of Commerce are positive steps. We are concerned, however, that using the National Bureau of Standards (NBS) as the base for NIST will result in a further loss of focus on its standards mission which is an essential base for technology and trade. We note that in recent years the NBS has been provided inadequate resources for its standards mission, and that when it assumed the larger NIST mission its budget was not increased. Science, engineering, and technology activities unrelated to standards should be extracted from the standards Institute and provided with adequate funding. Conversely, information standards, now partially addressed by the NIST's Institute of Computer Science and Technology, and by the National Telecommunications and Information Agency elsewhere in the Department of Commerce, have received too little attention and should be provided greater resources as part of the standards mission.

A National Technology Agency (NTA) should be established in the Department of Commerce, to strengthen support for U.S. technology. The NTA should be similar to the Defense Advanced Research Projects Agency (DARPA) but focused on the civilian sector and market-oriented. Functions of this agency should include:

- Research grants to technology research and development activities;
- Technology research "seed" contracts with industry, and
- Promoting cooperative industry/university activities in technology research and development, including manufacturing and process research and development.

Although we appreciate fully the support provided to engineering and technology (as distinct from science) by the National Science Foundation (NSF), we continue to hold that technology research needs a champion of its own. We there for conclude that the new Technology Agency's role should include the present technology functions of the NSF Engineering and Computer Directorates, including support of the NSF Engineering Research Centers.

**Elevating Technology in the President's Councils.** The President needs a top-level staff organization to provide on matters of science and technology policy. Technology affects every aspect of our national existence and every part of our government in fundamental ways. Technology is closely coupled with national competitiveness, an overwhelming economic concern to the United States today. Thus, in many ways like national security, technology is a broad and cross-cutting concern of our country. It is therefore critical to strengthen the voice and influence of technology on the President's staff and in his councils. We strongly support the President's announced intent to do this, and urge that early action be taken to make these changes a permanent part of the Government's structure.

**CONCLUSION:** The United States faces greater economic challenges today than ever before. Technology has an unquestionable role in meeting these challenges, at a time when international competitors are overtaking our erstwhile technological leadership. The present organization of the Federal government needs major restructuring to provide a clear and strong focus on technology, and to sustain U.S. technological leadership in an increasingly competitive world.

Mr. WALGREN. Thank you very much, Dr. Drew.

We will turn to Mr. Rice, who is the chairman of the Government affairs committee of the National Conference of Standards Laboratories.

Welcome to the committee, Mr. Rice.

**STATEMENT OF GEORGE O. RICE, CHAIRMAN OF GOVERNMENT AFFAIRS COMMITTEE, NATIONAL CONFERENCE OF STANDARDS LABORATORIES, ACCOMPANIED BY GARY M. DAVIDSON, PAST PRESIDENT, NATIONAL CONFERENCE OF STANDARDS LABORATORIES**

Mr. RICE. Thank you very much, Mr. Chairman, and members of the committee. My name is George Rice. I am chairman of the Government Affairs Committee for the National Conference of Standards Laboratories.

Mr. WALGREN. I want to apologize for this timer here. As you all know, it is critical that we move things along because if we don't, we lose the ability of the Members to stay with you, and then they have to meet commitments, and yet this timer is just being very erratic.

Mr. RICE. It needs to be calibrated.

Mr. WALGREN. I am trying to give you each about six minutes or so. So, you have five and a half coming. [Laughter.]

Mr. RICE. In closing—[Laughter.]

The NCSL, not Dr. Drew's NCSL nor Mr. Skaggs' NCSL, but the National Conference of Standards Laboratories, is an organization or company laboratories across the United States and indeed the world. I appear today primarily on behalf of the domestic industrial membership in the United States.

Again, we appreciate the opportunity you have afforded us. I think it is a singular opportunity because of the unanimity and the general nonpartisan nature with which this committee approaches these problems, and we appreciate it.

The single most often used word in these hearings, both the two prior days and today so far, has been technology. And rightly so. Our theme, then, for the remarks that I am going to make is technology, if you can't measure it, then it is not there.

At the risk of oversimplification, let me relate a couple of examples that I think might clarify that. First, from agriculture:

A friend of mine went to a farm in Nebraska, his uncle's farm, and in the tour was given a ride in the tractor. Now, you and I would think of a tractor as an outdoor-type thing with a steering wheel and gearshift and brakes and things. This thing had an enclosed cab. He climbed up into it and his uncle fired it up and the cab lit up like the cockpit of a 747—lights, digital displays and all kinds of things. He was amazed.

The farmer explained, however, that these were necessary. They are necessary for productivity. They are necessary for cost-cutting. How? Well, they had several dials and gauges and lights that control fuel. They had several more that control the planting of seeds and the application of fertilizers, all of it intended to make the farmer more productive. Measurement in action.

Another, little more modern area—that is, modern in the sense of the business area—is microelectronic chip production and application. A lot of companies have problems with humidity. When humidity gets low, we experience static electricity. Sometimes you reach out and touch a doorknob, and you can feel it, you know, when you get zapped.

When that happens to an microelectronic chip, it can be destroyed. It also can have its life expectancy reduced if it isn't destroyed. Therefore, some companies, many, stop production when the relative humidity gets to 30 percent or below.

In order to be sure that they are there, they have to use an accurate measuring device. They use a ten percent device. They usually require that they stop production when that device reads 40 percent. If they use a three percent accurate device, they can quit when it reads down to 33 percent. Three percent is about what we can do. That's about the best we can measure right now in the field.

The idea there is that if we can improve that area of technology, there would be an incremental improvement in production possibilities and costs saved.

Our measurement requirements committee, the National Measurement Requirements Committee of the National Conference of Standards Laboratories conducts surveys periodically. We just finished one last year and published a report that has been passed to the Committee Members. It looks like this. It is a thick document, but it has a four- or five-page summary in the front that you may wish to include in the record.

It identifies a tale of continuing deterioration in what our membership sees as the capabilities of the bureau. In 1982 there were 97 identified by this committee. In 1986 it had risen to 144. And by 1988, the last report, it is at 157.

The projection is that by 1995—I think it was 1995—1992, it will be to 2000, at the rate we are going, to correct them. In other words, the faster we go, the behinder we get. The budget that is before us, before you now that the Administration has sent down falls short of correcting the needs that our membership has seen over the years in the area of measurement and standards.

It has also been observed by this committee and by others here that it is totally lacking in some of the new initiatives that were proposed in the Trade Act last year.

The budget is good, we think, as far as it goes, but it just doesn't go far enough, and it is woefully inadequate in respect to our particular needs in the standards area.

We made a suggestion in the written testimony relative to—a suggestion that the Committee could possibly ask the Bureau to give a report on a couple of items of importance.

One is that what are NIST's view of the current measurement—is that me? [1]

Mr. WALGREN. Go ahead and finish your thoughts.

Mr. RICE. The idea there was to get this Committee to ask the Bureau to report on current measurement capabilities that they

[1] Editor's note: "Timer alarm rings."

have, any shortfalls that they see to the nation's needs, the views they may have in respect to the National Standards Laboratories' report that I mentioned, the results of previous process and quality control initiatives relative to correcting those deficiencies, and the need for any additional initiatives that they might see as necessary now.

The Bureau has made a start, particularly on the first item there, the current measurement capabilities and shortfalls in the measurement needs of the nation in the electronic area, which looks like an outstanding start to me, but it doesn't answer all of those questions.

Mr. Chairman, I appreciate the opportunity for being able to speak to you. I am sorry that I ran over my time a little bit, but the written testimony has everything that we wanted to say.

Thank you.

[The prepared statement of Mr. Rice, plus reports follow:]

STATEMENT OF

GEORGE O. RICE
CHAIRMAN GOVERNMENT AFFAIRS COMMITTEE
THE NATIONAL CONFERENCE OF STANDARDS LABORATORIES

BEFORE

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

ON THE

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
FY 1990 BUDGET

MARCH 23, 1989

STATEMENT BY GEORGE O. RICE
NATIONAL CONFERENCE OF STANDARDS LABORATORIES
BEFORE THE
HOUSE SUB-COMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY

MARCH 23, 1989

Mr. Chairman and Members of the Committee: My name is George Rice; I am Chairman of Government Affairs for the National Conference of Standards Laboratories. The NCSL is an international organization of metrology, standards, and calibration laboratories and of other organizations with an interest in those subjects. I appear before you today on behalf of the domestic industrial component of the NCSL. We appreciate the opportunity you have afforded us in this appearance to express to you our concerns for the National Institute of Standards and Technology and the budget proposed for it in 1990.

During these hearings the single most often used word, it seems to me, has been technology. My theme for these remarks, then, ladies and gentlemen, is "Technology: If you can't measure it, it isn't there!" What do I mean by this? No matter how elegant the scientific theory, until I can measure something in the physical world that confirms the theory it will always remain just a theory. Only when I can measure it am I able to translate the theory into a fact or a law. Only then is it possible to quantify and apply technology to products and services.

At the risk of oversimplification, let me relate an example or two to illustrate what I'm talking about. A friend of mine told me of a visit he recently made to his uncle's farm in Nebraska. This gentleman has farmed all his life, is solvent and lives comfortably. During a tour of the farm my friend was shown his uncle's tractor. Together they climbed into the enclosed cab and the uncle fired it up. To my friend's amazement, the dash lit up like the cockpit of a 747 - digital displays, multicolored lights, dials, and gauges everywhere. Most of us would envision a tractor with a gear shift, clutch, throttle, steering and brakes and probably no enclosed cab.

When asked, my friend's uncle explained the high tech tractor. In the first place, farming - in particular the use of tractors - is a high user of fuel and fuel costs money. So many of the gauges and displays allowed him to maximize his fuel economy, saving thousands of dollars a year. When seeding, flow sensors and displays helped him regulate the amount of seed for optimum planting. Similarly, other flow sensors dispersed fertilizer for



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optimum crop production. In other words, he used technology to maximize crop production and minimize the costs of fuel, seed, and fertilizer.

The example illustrates two parts of what I will be talking about. First, technology: the application of modern equipment to an age-old process. And second, the application of measurement and process control. In this case the technology and measurement capabilities existed. There are other cases, though, where either the technology does not exist or it is lacking in depth or breadth.

From an age-old process in agriculture to a high tech manufacturing operation for a different example. Many electrical devices, particularly microelectronic "chips", are susceptible to the effects of electrostatic electricity. We notice static electricity in dry weather when, after walking across a carpet, we reach out to touch a doorknob and ZAP! We always feel it, we usually hear it, and sometimes we see it. Our bodies have picked up a static charge which is discharged through our finger to the doorknob. The discharge of static charges through microelectronic devices can destroy the device or damage it so its life expectancy is shortened. To reduce the potential for this type of failure or reduction in reliability, manufacturers discontinue production when the relative humidity drops to less than 30%. However, if a sensor with an accuracy of plus or minus 10% is used to measure the humidity, the manufacturer - to be sure that production stopped at no less than 30% relative humidity - would have to cease operations when the sensor reads 40%. If the sensor's accuracy were improved to plus or minus 3% (about the best we can do at this time) then production would have to stop when the sensor reads 33%. With a true relative humidity of 30% the manufacturer with the more accurate sensor would be able to stay in production longer (the difference between 40% and 33% read on the sensors) when humidity was dropping.

All of us - we in the NCSL, managers and scientists at NIST, others in science and industry, Members of this Committee - are in favor of advancing technology and in transferring such advances to the private sector (or among and within the private sector) quickly and efficiently. Without a sound measurement system, though, neither the advancement we are seeking nor its swift and broad dispersion would be possible. For this reason we are concerned that this budget not only does not fund the new missions of the Institute, it does not provide the needed funds to correct inadequacies of previous budgets in the area of measurement services. And our membership has found that the inadequacies of the past are many and there are increasing numbers of them in the present.

In 1982 our Measurement Requirements Committee, which attempts to assess national measurement needs and whether NIST has the capability to meet them, conducted a survey and found 97 deficiencies. By 1986 the number had risen to 144 and to 154 in 1988. Our January 1989 report, copies of which were provided to the Committee Staff and your offices, details the deficiencies. The report gives specific requirements, current status at NIST, industries affected, application and impact, new requirements, and special comments. The report includes, as an example, a case where inaccuracy in flow measurements for natural gas causes volume discrepancies between sources and consumers totaling two-thirds of a million dollars a day, or a quarter of a billion dollars a year, every year.

Technology - If you can't measure it, then it isn't there!

For most of its history, the NBS (now NIST) led technology with measurement capabilities that far exceeded most industrial needs. These excess capabilities were in the bank, so to speak, waiting to be drawn upon by industry. From time to time, industry and science would make withdrawals from the account. However, beginning in the late '60s, the capabilities in industry began improving at a faster rate than those at the Institute. Before long, requests for measurement services - withdrawals from the account - began to be met with a response of insufficient account balance. NIST was no longer able to meet all of the needs of the nation. The causes of this situation were many and varied; sufficient blame is available to cover everyone. High on the list would be insufficient funding requests from disinterested Administrations.

Which brings me back to my theme: Technology - If you can't measure it, then it isn't there!

About twenty years ago, the then NBS made a change in the value of the US volt; the change was very small, in the low millionths of a volt. At the time, industry reaction was universal: So what? The change was too small to worry about. Next year, NIST is planning another change in the volt of about the same magnitude. Today, industry's reaction is much different. Today industry is concerned and a major effort is underway to minimize the impact of the change. What's different? For starters, today industry can and does routinely make measurements in the range of the change being considered. In other words, industry's capability has improved to the point that it rivals that of the state of the art at not only NIST but the world.

The proposed budget before you today falls far short of what is needed. We applaud what it does propose and among the initiatives - all of which are worthy and necessary - we would single out for specific mention two.

Our membership strongly supports the process and quality assurance initiative for chemical measurements. This initiative was proposed last year and, we think, authorized. However, it was never funded. We also support strongly the initiative for lightwave measurement technology, a rapidly developing new technology of great importance to the nation. We urge the Committee to approve all of the initiatives proposed in this budget.

However, the proposal does not go far enough, either in requesting funds for implementing the Trade Act mandates or in requesting sufficient funding to begin to correct prior year shortfalls. We are not expert in the intricacies of the Trade Act and, consequently, do not feel competent to assess what the funding needs are to implement it. We are certain the number is not trivial, but is necessary if we are going to keep the promises made last year.

Concerning prior year shortfalls in the measurement standard development and delivery arena, we do have a general feel for the costs involved. Based on estimates made several years ago to correct a fewer number of deficiencies, it is clear to us that in this specific category alone an investment of at least ten million dollars and probably nearer fifteen million dollars a year for a minimum of five years will be necessary to get us back to where we should be. In measurement standards and delivery services this investment would restore the "level field" in international markets each of us sees as not only necessary but right.

In these hearings two weeks ago, Mr. Boehlert lamented that the proposed budget seemed to be based on the assumption that we had arrived at the "promised land" in respect to the competitiveness issue. We are here to tell you that in respect to measurement standards and delivery services of NIST, we are not there: we are still wandering around in a desert of neglect and, in some cases, disinterest. Measurement standards provide the basis for sound, international competition.

The report of our National Measurement Requirements Committee, previously mentioned, identified 154 needs at NIST not now being met or being met at inadequate levels. To get a feel for the situation, I would like to quote a few items from that report:

> 118 of the 144 deficiencies identified in 1986 remain unresolved although 47 are presently under development or being studied. There is an implication that 34 of the 1986 deficiencies have been resolved; however, this is not necessarily a correct assumption. Although real progress has been made in resolving deficiencies, some of the items identified in 1986 have been combined to a single item and some have

been eliminated due to other causes. Nevertheless, with the fact that this year 44 new deficiencies are presented for consideration by NIST in their overall plan, the rate of accomplishment is still not satisfactory.

The report indicated priorities for the first four major categories as follows: **Flow measurement** (previously mentioned as contributing to excessive costs of a quarter billion dollars a year); **Atmospheric measurement** (necessary in efficiency in fuel use in aircraft and altitude separation between aircraft - a safety issue); **International standard coordination** (noted as necessary not only in commerce and in combating non-tariff barriers to trade but also in being able in the U.S. to respond quickly and effectively to proposed changes in international standards); and **Microwave measurement** (noted in the report and in previous hearings before this Committee as of critical importance to the Nation for both defense and commercial telecommunications). All of the 154 items noted in the report are important enough to concern its authors; they are important enough to concern you.

In prior years the Administration has sent up proposals that included initiatives for process and quality control for physical measurements as well as chemical measurements. Some of these were authorized and even funded. These "on again, off again" approaches to the budget of the National Institute of Standards and Technology are not meeting the nation's needs. It is time for this Committee to seek alternative approaches to solving this very difficult problem and to initiate the steps to return the Institute to its proper place among national standardizing laboratories. We have no magic wands, I'm sorry to say, but we do have a suggestion which we think might help lead to a longer term solution.

As Lincoln said "Before we can decide where to go and how to get there, we must first know where we are and whither we are tending." We would like to propose that the Congress investigate the lack of measurement capability at NIST which, in some cases, forces U.S. industry to use the laboratories of foreign nations for calibration services. As a starting point, it is recommended that NIST be asked to report on its assessment of the measurement needs identified by industry in the NMRC report, on the need for additional initiatives in the physical measurement area, on the results of previous initiatives in the process and quality control category, and on the funding necessary to implement all shortfalls and to restore the Institute to its previously held preeminent position in international measurement. The response to this assignment would enable this Committee to decide for itself "where we are and whither we are tending" and to then create the solutions so urgently cried for.

To improve anything, including technology, there has to be an investment - an investment of funds, of time and of dedication. Mr. Chairman, this budget proposal is inadequate in respect to the investment that will be required to correct years of neglect of its core mission. It is inadequate to implement the new missions in technology transfer, thus failing to make the investment necessary to prepare this nation for the future.

We have reviewed data and charts which track the budget of NIST over time and against a couple of pertinent bases. One such comparison shows NIST's Congressional appropriations vs. industry funded research and development. In constant dollars, industry funded R&D doubled from 1973 to 1987; NIST appropriations were at best flat and perhaps downward sloping very slightly over the same period. Against GNP the NIST appropriation is only a little better.

Our membership believes that, as is the practice in most industrialized nations, development and delivery of measurement and standardizing services are rightly the province of the federal government. Development of new and improved measurement services should be funded by congressional appropriations as a public good; delivery of these services should be borne by the user of the service through a fee structure. Last year NIST was allowed to began assessing a surcharge on all calibration fees; it was initiated at 8% of the fee and is scheduled to rise at 8% per year increments until it is at 40%. NIST has been directed by Congress to monitor the impact of the surcharge to assure that necessary use of NIST services is not reduced because of it. It is intended that this concern be directed at small and medium size firms which use the calibration services of NIST.

Our membership has reservations in respect to the surcharge. The principal hesitations are related to the ramping of the surcharge and the use to which the surcharge income will be put. We have reviewed the plans and methods employed in this effort and, so far, believe that NIST is on the right track. It is important to keep in mind that these funds are intended to be used to improve existing services and not to replace or even to increment Congressional appropriations. The latter are the investments that this nation must make in its future; the former assures that today's needs are able to be met.

Mr. Chairman, the National Conference of Standards Laboratories is a strong supporter of the National Institute of Standards and Technology. Most of our support and interest is in what we refer to as the core mission of NIST: research and development of measurement standards and techniques and delivery of those developments to industry, commerce and academia through calibration services and standard reference materials. But we firmly

support the other and newer missions of NIST as well; in particular, the technology transfer mission envisioned in the Trade Act is one we see as an investment in the future.

At the hearings earlier this month John Fluke, Jr. suggested that the Regional Technology Transfer Centers include other than machine shop technologies or that some of them be devoted to other manufacturing operations. We believe that is an outstanding idea; his recommendation that these centers also promote new and better metrology in the process of transferring the manufacturing technology is also welcomed by our membership.

In summation, this budget proposal is woefully lacking in most of the core areas of NIST's responsibilities and is manifestly inadequate in respect to eliminating shortcomings of prior years that are still present today. We believe that a start to a solution requires a clearer understanding of just how bad the situation is now and that the Congress should direct that a study, as outlined previously, be undertaken to aid in that understanding. Finally, we observe that the vision of an NIST with a wider role in advancing technology in the US through the technology transfer centers - that is, a NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY cannot be realized with budgets which are continually reduced or not even asked for.

Thank you, again, Mr. Chairman and Members of the Committee. I'd be happy to answer any questions you might have.

APPENDIX A

BIOGRAPHICAL SKETCH

GEORGE O. RICE
CHAIRMAN, GOVERNMENT AFFAIRS
NATIONAL CONFERENCE OF STANDARDS LABORATORIES

Rockwell International, Retired: 35 years experience in quality control and metrology.

Various management assignments in Rockwell International quality assurance and metrology including Director of Quality Assurance, manager of Quality Engineering, and manager of Metrology.

Various positions on the National Conference Standards Laboratories Board of Directors including Director, Executive Vice President, President, and Past President.

Various positions on the Precision Measurements Association Board of Directors including Treasurer, Executive Vice President, President, and Past President.

BS Physics, West Coast University
MBA Pepperdine University

The NATIONAL CONFERENCE OF STANDARDS LABORATORIES

The National Conference of Standards Laboratories is an international organization of standards and calibration laboratories. It has grown at the compound rate of 10% since inception of the organization 27 years ago. This growth demonstrates a continued concern for metrology and standards issues in defense and non defense sectors, in regulated and unregulated industries, and in manufacturing and service organizations. The NCSL membership will exceed 1,000 member organizations this year.

## APPENDIX A
## (Continued)

## NATIONAL CONFERENCE OF STANDARDS LABORATORIES

1800-30th Street, Boulder Colorado 80301
303.440.3339

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NMRC 89-01

# NATIONAL CONFERENCE OF STANDARDS LABORATORIES

# REPORT

# ON

# NATIONAL MEASUREMENT REQUIREMENTS

1 JANUARY 1989

# NATIONAL CONFERENCE OF STANDARDS LABORATORIES (NCSL)

## Update to the NMRC 86-01 Report

Prepared by

| | | |
|---|---|---|
| National Measurement Requirement Committee (NMRC) | - | L.H. Baker, Chairman AES Rockwell International. |
| NMRC DC - Low Frequency Metrology Subcommittee | - | Don Dalton, Chairman John Fluke Mfg. Co., Inc. |
| NMRC RF - Microwave Metrology Subcommittee | - | Pat Nolan, Chairman Lockheed Missiles and Space Co. |
| NMRC Electro - Optics Metrology Subcommittee | - | Tom Larason, Chairman NWSSB Corona Annex |
| NMRC Temperature - Pressure Metrology Subcommittee | - | L.H. Baker, Chairman AES Rockwell International |
| NMRC Physical - Dimensional Metrology Subcommittee | - | R. Tobias, Chairman TRW |
| NMRC Flow Metrology Subcommittee | - | Steve Croasmun, Chairman NWSSB Corona Annex |

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| 6 | Physical - Dimensional Metrology | 6-0 |
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| 8 | Final Comments | 8-0 |
| 9 | References | 9-0 |

# INTRODUCTION

## BACKGROUND

During 1982, over 400 organizations within the United States (346 industry, 61 government, and 4 universities) responded to a survey conducted by the National Conference of Standards Laboratories' National Measurements Requirements Committee (NMRC). The broad objectives of the original survey were to:

I.) Identify requirements for new and/or improved calibration services from the National Bureau of Standards (NBS) that are necessary for national interests including commerce, international competitiveness and defense preparedness.

II.) Identify new measurement requirements to establish or improve technical, quality, and productivity aspects of individual organizations.

The report of the survey (ref.[1]), published in May 1983, was widely distributed and endorsed by industry and government agencies. NBS addressed many issues indicated in the report and a response (ref.[2]) was released in March 1984. Further updates to the response and additional NBS calibration services are shown in references [3] through [8].

Essentially, the 1982 survey identified critical needs for increased NBS support in the form of new or improved NBS calibration services in over 20 measurement areas. The survey report noted that the impact of not having the NBS calibration service at the time or in the near future would significantly affect the following:

a.) Quality of goods and services.

b.) Readiness of national defense capabilities.

c.) International Commerce and competitiveness.

d.) Productivity improvement.

e.) Verifiable product performance.

f.) High technology product development.

In 1986 to determine the status of the national measurement requirements, especially for new and improved NBS calibration services, the NMRC subcommittees reassessed the deficiencies noted in 1983 by comparing them to the NBS responses (references [2] through [9]) and by obtaining additional input from the industrial community. Two open conferences were held to assure broad assessment and discussion of requirements and in all cases, NBS personnel were consulted to assure correctness of the information especially in terms of present and future NBS plans.

Each of the 1986 subcommittees summarized their results by measurement parameter. The measurement parameter summaries listed measurement requirements identified in the 1982 survey that were still not satisfied, the 1986 NBS status, industries and applications affected by the deficiency with related impact, and new requirements had been determined.

In order to gain an appreciation of the needs for improved standards calibration support, the results of each subcommittee were summarized into individual tables. The tables showed that 87 of the original 97 deficiencies identified in the 1982 survey remained unresolved and although 43 of these were in work at NBS, an additional 58 deficiencies had been identified by the NMRC subcommittees in the interim. Therefore, it was obvious that with the level of NBS resources being applied, the rate of accomplishment was inadequate.

## SUMMARY OF RESULTS

The NMRC was reorganized to incorporate a new Flow Metrology subcommittee in 1988 formed by subdividing the previous Temperature-Pressure-Flow Metrology subcommittee with some allied parameters that had been covered by the Dimensional-Physical Metrology subcommittee. This action was taken in view of the fact that flow measurement had not been given the attention due and it was a discipline that impacted a wide variety of consumer industries with fiscal importance that warranted special attention.

The 1989 review of the capabilities of the National Institute of Standards and Technology (NIST, formerly NBS) focused upon the identification of key parameters, those whose lack causes significant problems, as well as the broad overview of all missing capabilities identified in previous surveys.

The data presented in this report by the six subcommittees was gathered during 1988. Care was taken in checking with personnel from the NIST (as listed by each subcommittee) to assure the correctness of the information. The results of the survey have been summarized in the following tables. These tables show that 110 of the 144 deficiencies identified in 1986 remain unresolved although 47 are presently under development or being studied. There is an implication that 34 of the 1986 deficiencies have been resolved; however, this is not necessarily a correct assumption. Although real progress has been made in resolving deficiencies, some of the items identified in 1986 have been combined to a single item and some have been eliminated due to other causes. Nevertheless, with the fact that this year 44 new deficiencies are presented for consideration by NIST in their overall plan, the rate of accomplishment is still not satisfactory. Considering the progress made since the original 1982 National Measurement Requirements Survey, the relative gain in capability relative to the discrepancies that have been identified is far from satisfactory. In fact, if we extrapolate the rate of progress in the negative sense, by the year 1995, there will have been 200 added deficiencies with solutions provided for about 60; hence, we will be studying 250 problem areas in NIST services.

PRIORITIES

A key goal in the presentation of this report is to define the relative priority of the deficiencies identified by the subcommittees. In the 1986 report, the subcommittees identified 144 deficiencies and of those, 30 were under development by NIST (then NBS). For the 1986 report, as for the 1982 report, each of the subcommittees felt that to establish priorities would detract from the message presented and would create an impression that the deficiencies listed at the "bottom" of a priority list would be deemed to be "unimportant"; hence, ignored. For this report; however, priorities will be presented that reflect the importance of correcting deficiencies, the importance of continuing to develop capabilities, and the importance of maintaining of capabilities at the existing level.

In each instance, the following items have been selected because solutions by NIST will benefit a broad spectrum of users. Solutions to or satisfaction of deficiencies in some cases may not be the provision of a single calibration capability; but, may require that NIST provide guidance as well as capability for solutions of problems associated with measurement requirements. In some cases, the NIST is currently engaged in pursuing the task identified as a priority item. Identification of such tasks in this report are included to reinforce the justification for continuation of the effort.

A. Flow Measurement Improvement

NIST is has been engaged in fundamental flow research concerning the technology of orifice flow metering (ref xx) since 1983. This item is included in the priority list to encourage the continuation of the effort and to show that fundamental research on the part of NIST is valuable to the economy. In the reference document, "Workshop on Fundamental Issues in Orifice Metering", pp 31, one rational for the studies under taken was "The rising price of natural gas is producing a corresponding rise in demands for reduction in uncertainty currently associated with orifice meter measurements. Such measurements are the basis for custody transfer of this valuable product. The dollar value of unaccounted for gas resulting from this metering is difficult to quantify precisely; however, in the introduction to this report it is estimated that this is equivalent to perhaps two thirds of a million dollars a day of gas as averaged over the USA annually.------". NIST research on this and similar high value efforts in fundamental measurement technology can be beneficial.

B. Improved Atmospheric Range Pressure Standards, (Manometry)

The atmospheric pressure range is assumed to include absolute pressures related with high altitude flight, from above 40 000 feet for military aircraft and near that for commercial aircraft, to those associated with common measurements in many industries. The absolute pressure range is from approximately 5 psia to near 500 psia. NIST capability is based upon the ultra sonic manometer and well characterized piston gages; however, they are not able to respond to requests for improved calibration service in this region of measurement. The need to improve the capability comes from both aircraft and industrial bases. In the pharmaceutical industry, pressure measurements relate to the purity of product processed in "Freeze Drying" and similar operations where reproducibility is of prime importance. For aircraft, both commercial and military, aircraft engine performance factors involving pressure and pressure ratio measurements, which relate to efficiency of operation; hence, operating costs are becoming increasingly effective. More precise measurements, on board accuracies of 100 ppm (0.01 %), are desired to further improve measurement but are not available because of NIST limitations. The benefits of providing the improved service are difficult to quantify but improved aircraft efficiency is a desirable attribute. Further benefits of improved service lie in the area of pressure altimetry which relates to the altitude separation of commercial airline traffic; hence, safety.

C. Coordination with International Standards

NIST also serves as the link with the International Committee on Weights and Measures (CIPM) and to maintain the standards that represent the units of measurement controlled by the various subcommittees of the CIPM. When changes in the international units (SI) are proposed or planned to be implemented, NIST accomplishes the change for the US Measurement System. Accordingly, NIST must provide the coordination with users of these units of measurement to assure dissemination in a timely manner and to minimize the impact of any change to the US system of measurements. Therefore, NIST activities associated with CIPM adjudicated changes must have a high, if not the highest, priority while not detracting from needs to correct deficiencies. The years 1989 to 1990 are unusual for the fact that four changes in the values of basic units will become effective in 1990 requiring significant coordination for the remainder of 1989.

National and international standards, monitored by the CIPM and the International Organization for Legal Metrology (OIML), provide the basis for uniform and fair trade and the determination that the performance and quality of goods and services will meet requirements and expectations. At this time barriers to international trade exist due to the lack of recognition of the US National Measurement System and its services and to some of the limited agreements on the recognition of equivalence of national standards. Also, barriers to trade and limitations in the execution of contracts with US government agencies exist due to the lack of recognition of equivalence of national standards between NIST and the national laboratories of other countries. Therefore, as well as the present activity regarding the change in units of measurement for the volt, ohm, unit of mass and the new temperature scale that are now under way, the NIST should emphasis their coordination with CIPM and OIML in other activities that offer progress towards the mutual recognition of basic and derived units of measurement between national laboratories.

D. Microwave Measurement Technology

Progress has been made by NIST in recent years in the field of microwave measurements; however, relative to broader national measurement needs the progress is limited. Measurement support continues to be lacking for the industrial base that is not concerned with the DoD. The RF/Microwave industry, exclusive of DoD, is concerned with an international market plaqe where competitiveness is hampered by the measurement support to ensure compatibility, product performance, quality and other measurement dependent factors. Emerging applications for the microwave industry that require support, both for the

international marketplace and for applications within the continental US, are:

a) High definition television.

b) Broadcast systems for Satellites.

c) Wind shear detection systems for airplanes.

d) Local communications/radar for industrial applications.

e) Communications/radar/landing systems at airports.

f) etc.

Revolutionary changes in the application of microwave technology, beyond those listed, are anticipated that will challenge US industry and NIST to exploit new markets that will require measurement support.

The NCSL through the efforts of the NMRC and the IEEE Committee to Promote National Microwave Standards (PNMS) have emphasized the needs of the former NBS and now NIST to develop capabilities to support the needs of the RF/Microwave community beginning with the original NMRC report in 1983, the 1986 NMRC report, and with this 1989 report.

## DC/LOW FREQUENCY METROLOGY

### NUMBER OF ITEMS IDENTIFIED FOR EACH CATEGORY

| CATEGORIES | OLD REQUIREMENTS STATUS | | | | NEW REQUIREMENTS STATUS | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | NC | PS | US | UD | NC | PS | US | UD | |
| AC Voltage | | 3 | | 2 | | | | | 5 + 0 = 5 |
| Capacitance | 2 | 1 | 1 | | | | 1 | | 4 + 1 = 5 |
| DC Voltage | | 1 | | 3 | | | | | 4 + 0 = 4 |
| DC/AC Resist | 2 | 1 | 1 | 3 | | | 2 | | 7 + 3 = 10 |
| A/D and D/A | | | | | 2 | 1 | | 1 | 0 + 4 = 4 |
| DC/LF Power | | 2 | | 2 | | | | | 4 + 0 = 4 |
| DC/LF Ratio | | | | | | | 3 | | 0 + 3 = 3 |
| Inductance | | | | | | | 3 | | 0 + 3 = 3 |
| LF Phase Angle | | 1 | | 3 | | | | | 4 + 0 = 4 |
| Magnetic Field | 1 | | 1 | | 1 | | | | 2 + 1 = 3 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| TOTAL | 5 | 9 | 3 | 13 | 3 | 1 | 9 | 1 | 30+14= 44 |
| | 30 | | | | 14 | | | | |

Key to Abbreviation:
NC => No NIST Capability for Items in this category.
PS => Partial NIST Capability for Items in this Category.
US => Unknown NIST Status for Items in this Category.
UD => Under NIST Development for Items in this Category.

## RF/MICROWAVE METROLOGY

### NUMBER OF ITEMS IDENTIFIED FOR EACH CATEGORY

| CATEGORIES | OLD REQUIREMENTS STATUS | | | | NEW REQUIREMENTS STATUS | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | NC | PS | US | UD | NC | PS | US | UD | |
| Impedance/ Quality Factors | 3 | 1 | | 1 | 3 | | | | 5 + 3 = 8 |
| Low/High Power | 4 | 3 | | 2 | 1 | | | | 9 + 1 = 10 |
| Noise Temp | 2 | 1 | | 1 | | | | | 4 + 0 = 4 |
| Attenuation | 2 | 2 | | | 1 | 2 | | | 4 + 3 = 7 |
| Phase Noise | | 1 | | | 1 | | | | 1 + 1 = 2 |
| Antenna Gain | | | | 1 | | | | | 1 + 0 = 1 |
| Power Density | | 1 | | | | | | | 1 + 0 = 1 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| TOTAL | 11 | 9 | | 5 | 6 | 2 | | | 25+8= 33 |
| | 25 | | | | 8 | | | | |

Key to Abbreviation:
NC => No NIST Capability for Items in this category.
PS => Partial NIST Capability for Items in this Category.
US => Unknown NIST Status for Items in this Category.
UD => Under NIST Development for Items in this Category.

## ELCTRO-OPTICAL METROLOGY

### NUMBER OF ITEMS IDENTIFIED FOR EACH CATEGORY

| CATEGORIES | OLD REQUIREMENTS STATUS | | | | NEW REQUIREMENTS STATUS | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | NC | PS | US | UD | NC | PS | US | UD | |
| AmbientBlackbody | | 2 | | | | | 1 | | 2 + 1 = 3 |
| Cryo Blackbody | 1 | | | | | | | | 1 + 0 = 1 |
| Detector Sp Rsp | | 2 | | | | | 1 | | 2 + 1 = 3 |
| FTIR Scale Stds | | | | 1 | | | | | 1 + 0 = 1 |
| IR Transmission | | | | 1 | | | | | 1 + 0 = 1 |
| Reflectance,Dif | | | 1 | | | | | | 1 + 0 = 1 |
| Reflectance,Spec | | | | 1 | | | | | 1 + 0 = 1 |
| Laser Profile | 1 | | | | | | | | 1 + 0 = 1 |
| Laser Mode | 1 | | | | | | | | 1 + 0 = 1 |
| Laser Power | | 1 | 2 | 1 | | | | | 4 + 0 = 4 |
| Laser Atten | | | | 1 | | | | | 1 + 0 = 1 |
| Laser Pointing | | | 1 | | | | | | 1 + 0 = 1 |
| Optical Fibers | | | | 3 | | | | | 3 + 0 = 3 |
| Optical Power | | 1 | | | | | | | 1 + 0 = 1 |
| Opt Time Domain | 1 | | | | | | | | 1 + 0 = 1 |
| Opt Det Spec Rsp | | 1 | | | | | | | 1 + 0 = 1 |
| Fiber Opt Atten | | | 2 | | | | | | 2 + 0 = 2 |
| Opt Fiber LAN | | | | 1 | | | | | 1 + 0 = 1 |
| Opt Fib Back Rfl | | | | | | | 2 | | 0 + 2 = 2 |
| TOTAL | 4 | 7 | 6 | 9 | | | 4 | | 26+4= 30 |
| | 26 | | | | 4 | | | | |

## PRESSURE/TEMPERATURE METROLOGY

### NUMBER OF ITEMS IDENTIFIED FOR EACH CATEGORY

| CATEGORIES | OLD REQUIREMENTS STATUS | | | | NEW REQUIREMENTS STATUS | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | NC | PS | US | UD | NC | PS | US | UD | |
| Pressure | 2 | 2 | 2 | | | 1 | | | 6 + 1 = 7 |
| Vacuum | | | 1 | 2 | | | 1 | | 3 + 1 = 4 |
| Leak Rate | | 1 | | | | | | | 1 + 0 = 1 |
| Temperature | | | 1 | 1 | | | 1 | | 2 + 1 = 3 |
| Elect Conduct | | | | | | | | | 0 + 0 = 0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| TOTAL | 2 | 3 | 4 | 3 | | 1 | 2 | | 12+3= 15 |
| | 12 | | | | 3 | | | | |

Key to Abbreviation:
NC => No NIST Capability for Items in this category.
PS => Partial NIST Capability for Items in this Category.
US => Unknown NIST Status for Items in this Category.
UD => Under NIST Development for Items in this Category.

## PHYSICAL/DIMENSIONAL METROLOGY

## NUMBER OF ITEMS IDENTIFIED FOR EACH CATEGORY

| CATEGORIES | OLD REQUIREMENTS STATUS | | | | NEW REQUIREMENTS STATUS | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | NC | PS | US | UD | NC | PS | US | UD | |
| Coord Meas Mach | 2 | | | 1 | 1 | | | 2 | 3 + 3 = 6 |
| Laser Length | | | | | 2 | | | | 0 + 2 = 2 |
| Thd Plug/Ring | | | | | 2 | | | | 0 + 2 = 2 |
| Surf Roughness | | 3 | | | | | | | 3 + 0 = 3 |
| Gage Blocks | | 2 | | | 2 | | | | 2 + 2 = 4 |
| Cylindrical Std | | | | | 1 | | | | 0 + 1 = 1 |
| Angle | | | | | 1 | | | | 0 + 1 = 1 |
| Mass | 1 | | | | 1 | | | | 1 + 1 = 2 |
| API Thd/Ring | | | | | | 1 | | | 0 + 1 = 1 |
| Hardness | 1 | | | | | | | | 1 + 0 = 1 |
| Haze | 1 | | | | | | | | 1 + 0 = 1 |
| Gloss | 1 | | | | | | | | 1 + 0 = 1 |
| | | | | | | | | | |
| | | | | | | | | | |
| TOTAL | 6 | 5 | | 1 | 10 | 1 | | 2 | 12+13= 25 |
| | 12 | | | | 13 | | | | |

Key to Abbreviation:
NC => No NIST Capability for Items in this category.
PS => Partial NIST Capability for Items in this Category.
US => Unknown NIST Status for Items in this Category.
UD => Under NIST Development for Items in this Category.

FLOW METROLOGY

NUMBER OF ITEMS IDENTIFIED FOR EACH CATEGORY

| CATEGORIES | OLD REQUIREMENTS STATUS | | | | NEW REQUIREMENTS STATUS | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | NC | PS | US | UD | NC | PS | US | UD | |
| Gas Flow | | | | 1 | | | | 1 | 1 + 1 = 2 |
| Liquid Flow | 1 | 1 | 1 | | | | | 1 | 3 + 1 = 4 |
| Hygrometry | | | 1 | | | | | | 1 + 0 = 1 |
| Particle Stds | | | | | | | | | 0 + 0 = 0 |
| Viscosity | | | | | | | | | 0 + 0 = 0 |
| Fluid Density | | | | | | | | | 0 + 0 = 0 |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| TOTAL | 1 | 1 | 2 | 1 | | | | 2 | 5+2= 7 |
| | 5 | | | | 2 | | | | |

Key to Abbreviation:
NC => No NIST Capability for Items in this category.
PS => Partial NIST Capability for Items in this Category.
US => Unknown NIST Status for Items in this Category.
UD => Under NIST Development for Items in this Category.

## SUMMARY OF ALL SUBCOMMITTEES

### NUMBER OF ITEMS IDENTIFIED FOR EACH CATEGORY

| CATEGORIES | OLD REQUIREMENTS STATUS | | | | NEW REQUIREMENTS STATUS | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| | NC | PS | US | UD | NC | PS | US | UD | |
| DC/ Low Frequency | 5 | 9 | 3 | 13 | 3 | 1 | 9 | 1 | 30+14= 44 |
| RF/ Microwave | 11 | 9 | | 5 | 6 | 2 | | | 28+8 = 36 |
| Electro-Optics | 4 | 7 | 6 | 9 | | | 4 | | 26+4 = 30 |
| Temperature/ Pressure | 2 | 3 | 4 | 3 | | 1 | 2 | | 12+3 = 15 |
| Physical/ Dimensional | 6 | 5 | | 1 | 10 | 1 | | 2 | 12+13= 25 |
| Flow | 1 | 1 | 2 | 1 | | | | 2 | 5+2 = 7 |
| TOTAL | 29 | 34 | 15 | 32 | 19 | 5 | 15 | 5 | 110+44=154 |
| | 110 | | | | 44 | | | | |

Key to Abbreviation:
NC => No NIST Capability for Items in this category.
PS => Partial NIST Capability for Items in this Category.
US => Unknown NIST Status for Items in this Category.
UD => Under NIST Development for Items in this Category.

## SUBCOMMITTEE I: DC - LOW FREQUENCY AC

### CATEGORIES

| | |
|---|---|
| Capacitance | Current (AC) |
| Current (DC) | Electric Power |
| Inductance | Magnetics |
| Phase | Resistance (DC) |
| Resistance (AC) | Volt (AC) |
| Volt (DC) | A/D - D/A |

### INTRODUCTION

It has not been the intention of this group to describe the capability of the National Institute of Standards and Technology (NIST, formally NBS), but to determine new or improved service requirements in the Dc and Low Frequency subcommittee. The original report (dated September 1986, Rev.2 April 1987) did not include all the comments of our responders but only those items that have showed up in multiple occasions as immediate or near future requirements. No attempt was made to forecast any long term increases in requirements. This update to the report includes a new look at capability and incorporated the estimates for economic impact if known.

## COMMITTEE MEMBERS

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---


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Parameters: AC Voltage

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Parameters: Phase Angle Meters

## PARAMETER: AC VOLTAGE

UNITS: Volt (V)

### REQUIREMENTS

1.) Reduce turnaround time to 4 weeks.
2.) New AC Voltage transfer standard with 2.5 ppm transfer uncertainty.
3.) AC Voltage MAP to 1 MHz with total uncertainty at +/- 10 ppm at mid-band (40 Hz to 20 kHz).
4.) Better than 5 ppm absolute accuracy 40Hz - 20KHz, from 0.5V - 1KV.
5.) At least 25ppm absolute accuracy 40Hz - 20KHz, 1mv to 0.2V.

### STATUS AT NIST

1.) Automated calibration service with mid-range uncertainies less than 20ppm; larger uncertainties at low voltages down to 2mv or high frequencies (up to 1MHz).
2.) Studying new Multi-Junction Thermocouple (MJTC) and special Single-Junction Thermocouple (JTC) plus solid state converters.
3.) Making preliminary feasibility studies of MAPs.

### INDUSTRIES AFFECTED

1.) Commercial Industries
2.) Department of Defense
3.) Industrial Manufacturing and Service

### APPLICATION AND IMPACT

1.) Hindering development and calibration of new products.

### NEW REQUIREMENTS

None

### SPECIAL COMMENTS

None

**PARAMETER: CAPACITANCE**

UNITS: Farads (F)

REQUIREMENTS

1.) Capacitance MAP service, 10 pF to 1 mF at frequencies from 1 kHz to 1 MHz.
2.) Measurement of the dissipation factor of standard capacitors.
3.) Calibration of four terminal standard capacitors with values up to 1 F at 100 Hz, 120 Hz, and 1 kHz.
4.) Capacitor for Calibrating high frequency capacitance bridges.

STATUS AT NIST

1.) MAP services in the capacitance area have been suspended until new transport standards can be obtained. Future work in this area is expected to increase the frequency range.
2.) Dissipation factor measurements are not available at the present time but future work is expected to provide that service with an accuracy better than 1 ppm.
3.) Calibration services limited to 0.1 uF at frequencies up to 10 kHz.
4.) Unknown
A.) Unknown

INDUSTRIES AFFECTED

1.) Electronic (Component and Instrument)
2.) Department of Defense
3.) Aerospace Industry

APPLICATION AND IMPACT

1.) Limiting usage of C bridges at frequencies above 1 kHz.

NEW REQUIREMENTS

A.) Extend the frequency range of the calibration of four terminal capacitors to frequencies above 1 MHz with accuracies of +/- 0.01%.

SPECIAL COMMENTS

None

## PARAMETER: DC VOLTAGE

UNITS: Volt (V)

### REQUIREMENTS

1.) 10 Volt MAP and calibration service. Uncertainties 0.1 - 0.3 ppm at 10 volts.

2.) 0.01 to 1000 Volt MAP or calibration service. Uncertainties 1 - 10 ppm.

3.) 1.018 Volt MAP. Uncertainty 0.1 - 0.2 ppm. Reduce turnaround time to 4 weeks.

4.) Coordination of the impending change in the legal volt.

### STATUS at NIST

1.) The need for a 10 Volt MAP can be met with the present 10 Volt calibration service. A dual 10 Volt and 1.018 solid-state voltage standard is being developed for future (2 - 3 years) 1 Volt and 10 Volt MAP programs.

2.) Scaling program for lower voltages will be available in 2 - 3 years. Higher voltage scaling is planned but will take longer. A Combination of scaling hardware and training is being considered.

3.) Fast turnaround times will be practical when the new 10V/1.018V solid-state voltage standard is available. At the present, process time is limited by the settling time of the unsaturated cells to at least four weeks (at NIST) for hand-carried, good cells.

4.) A special NIST-Industry-Department of Defense committee has been formed to facilitate the transition to the new voltage value. A guideline for accomplishing the change will be published by March 1988.

### INDUSTRIES AFFECTED

1.) Department of Defense
2.) Aerospace industry
3.) Instrument manufacturers

### APPLICATION and IMPACT

Measurements for quality and productivity can be limited by the lack of adequate calibration programs.



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PARAMETER: DC VOLTAGE (Continued)

NEW REQUIREMENTS

None

SPECIAL COMMENTS

None

## PARAMETER: DC AND AC RESISTANCE

UNITS: Ohm

### REQUIREMENTS

1.) Calibration service for AC resistance; 0.1 to $10^7$ ohms, four terminal:
   a) 20 Hz to 10 MHz, better than 0.1% accuracy.
   b) 20Hz - 20KHz, 10ppm accuracy.
   c) 20KHz - 100KHz, 100ppm accuracy.
2.) Reinstate high value calibration service ($10^{11}$ - $10^{15}$ ohms, three terminal, better than 0.2% accuracy.) Improved standard up to $10^{15}$ ohms.
3.) Calibrate shunts to currents of 3000 amperes with accuracies up to 50 ppm.
4.) Reinstate calibration services for ratio devices.
5.) Method to calibrate synthesized ohms from dc to 100KHz.
6.) Measure noise of synthesized resistance.
7.) Capability to determine polar coordinates for resistance.

### STATUS AT NIST

1.) No plans for above 1 ohm and 10 kHz.
2.) Services available for range 1 ohm to 10 ohms between 1.5 and 500 volts. Automated measurement system is installed.
3.) Presently capable of 1k amperes at 0.01%. No plans to improve capability. National Research Council of Canada goes to 4.6k amps (AC) and meets the low demand.
4.) No plans to reinstate services for ratio devices.

A.) Unknown

B.) Unknown

### INDUSTRIES AFFECTED

1.) Aerospace Industries
2.) Component Manufacturing
3.) Research and Development
4.) Nuclear Weapon Production
5.) Particle Beam Accelerators

### APPLICATION AND IMPACT

1.) There are "paperwork" difficulties that aerospace companies have dealing with Canada's NRC since they have no agency representation in the U.S..

**PARAMETER: DC AND AC RESISTANCE (Continued)**

NEW REQUIREMENTS

A.) Platinum Resistance Thermometer (PRT) need for 100 ohm service.
B.) Provide support for HP bridges (4-port, 8-terminal) resistors to 10 Mhz.

SPECIAL COMMENTS

1.) Concern was expressed about trend toward NIST reduction in service and increased turnaround time.
2.) A need was also noted for more seminars and technical literature.
3.) NIST states that future seminars on ratio measurements will be considered.

**PARAMETER: A/D and D/A**

REQUIREMENTS:

1.) A methodology to determine accuracy of a/d and d/a at specified settling times.

2.) An approach to determine monotonicity of high resolution a/d's and d/a's.

3.) An definition of linearity

4.) A method for characterizing the linearity of high speed a/d converters.

STATUS AT NIST:

1.) NIST provides a static calibration service for high resolution a/d's and d/a's. As a special service, NIST can support 2 PPM at a settling times to 2 microseconds. In the future, (about 2 years) NIST is planning on providing a transportable reference waveform generator to be used to characterize settling time measurements. This unit will have well defined settling characteristics at specified voltages and hopefully meet the needs of industry for testing a/d's and d/a's.

2.) At present NIST does not provide calibration service for monotonicity although support is provided for integral and differential linearity. The user is left to determine the monotonicity from this data.

3.) NIST defines linearity by determining the positive and negative full scale end points. This determines the straight line and deviations from this line represent linearity errors.

4.) At present no support is provided. A IEEE subcommittee for waveform measurement and analysis is providing guidelines in this area. NIST will recommend techniques and will be developing papers dealing with high speed a/d and spectral purity.

INDUSTRIES AFFECTED:

1.) Commercial Industries
2.) Department of Defense
3.) Component Manufacturing
4.) Instrumentation manufactures

**PARAMETER: A/D and D/A (Continued)**

**APPLICATION AND IMPACT:**

At present many a/d and d/a are being introduced to the marketplace that are cost effective and provide performance at levels that are becoming difficult to support. Many of these parts are being used in the commercial audio markets and a variety of DSP techniques. It is important that services be provided to properly support and characterize these devices.

PARAMETER: DC/LOW FREQUENCY ENERGY AND POWER

UNITS: Joules and Watts

REQUIREMENTS

1.) Reduce low frequency energy and power calibration uncertainty to 50 - 100 ppm level.
2.) Provide calibration at any power factor.
3.) Provide VAR/VAR hour calibration at 200 ppm uncertainty level.
4.) Extend the range of inputs for which calibrations are made:
    a.) Potential to 600 V
    b.) Current to 50 A
    c.) Frequency to 5 kHz

STATUS AT NIST

1.) Present low frequency energy/power calibration uncertainty 500 ppm; working to goal of 100 - 500 ppm uncertainty on a routine basis.
2.) Present power factor capability if 0.5 and 1.; working to develop facility for any power factor.
3.) No VAR capability now; new facility will have VAR capability.
4.) Present calibrations can be at many fixed potentials from 110 to 480 volts; many currents from 0.5 to 75. amperes, and at power frequencies from 50 Hz to 400 Hz. Facility being developed will have potential from 10 to 240 volts, current from 0.01 to 10. amperes and frequencies from 40 Hz to 10 kHz.

INDUSTRIES AFFECTED

1.) Electric Utilities
2.) Instrument Manufacturers
3.) Aerospace Industry

APPLICATION AND IMPACT

1.) Power/energy metering (100 ppm for one nuclear plant output for one year is about 1 million kilowatt hours).
2.) Operating efficiency determination for AC electrical devices.
3.) Production line instrument test.

NEW REQUIREMENTS

None

SPECIAL COMMENTS

None

**PARAMETER: DC/LF RATIO**

**UNITS: Ratio**

**REQUIREMENTS**

1.) No old requirements.

**STATUS AT NIST**

Unknown

**INDUSTRIES AFFECTED**

1.) Electronic Instrument Manufacturers
2.) Aerospace

**APPLICATION AND IMPACT**

**NEW REQUIREMENTS**

A.) Existing DC Ratio devices, such as the 7-dial Kelvin-Varley divider and the self-calibrating reference dividers, are marginally acceptable for the scaling at the accuracies required for consistency with the more accurate standards. Needed are the devices which provide ratios with uncertainties smaller than 0.1 ppm of output at ratios of 10:1 and 100:1, and scaling devices, such as Kelvin-Varley dividers, for finely subdividing the basic values, and decade multiples of them, to uncertainties of +/- 0.1 ppm or smaller.

B.) Existing high accuracy ratio devices for AC do not operate above 10 kHz. There is a current need for high accuracy (<= 100 ppm) scaling of AC voltage to frequencies of 1 MHz and lesser accuracy (0.1% uncertainty) to 10 MHz. The major problem is in obtaining a few millivolts from the 0.5 volt standards commonly available.

C.) While it is true that ratio is a dimensionless quantity for which no standard is required, it is necessary to provide a means by which one may verify that ratio/scaling apparatus provides the accuracy claimed. This can be accomplished by means of a calibration service which compares a customer's ratio device to a standard device or by means of a Measurement Assurance Program which enables a customer to verify his realization of a particular multiple or sub-multiple of various quantities.

**SPECIAL COMMENTS**

None

PARAMETER: INDUCTANCE

UNITS: Henrys (H)

REQUIREMENTS

1.) No old requirements.

STATUS AT NIST

A.) Unknown
B.) Unknown
C.) Unknown

INDUSTRIES AFFECTED

1.) Aerospace Industry
2.) Electronic Instrument Manufacturers

APPLICATION AND IMPACT

1.) Used in switching power supplies for space-born and missile guidance systems.

NEW REQUIREMENTS

A.) Appropriate calibration service up to 10 MHz.
B.) Measurement techniques and procedures.
C.) Artifact design.

SPECIAL COMMENTS

1.) The items identified under "New Requirements" constitute a recent development and demand by industry and hence warrant attention by NIST.

## PARAMETER: LOW FREQUENCY PHASE ANGLE

UNITS: Degrees

### REQUIREMENTS

1.) Provide low frequency phase angle calibration uncertainty at +/- 0.005 degree level.
2.) Provide calibrations for frequencies form about 20 Hz to 100 kHz.
3.) Most users require potential : potential phase measurement at 20 mV to 300 volts, but some require potential : current and current : current up to 50 amperes.
4.) A workshop/seminar on precision phase measurement procedures.

### STATUS AT NIST

1.) Phase angle calibration is offered as a special test; NIST is working toward +/- 0.005 degree uncertainty for low frequency balanced signals and up to +/- 0.02 degree at high frequency.
2.) The standard is a two-channel source. The NIST trial program now calibrates for 2 Hz to 5 kHz, extension for 10 Hz to 50 kHz is planned.
3.) The NIST trial program calibrates potential : potential and potential : current at potentials from 0.25 V to 100 V and currents up to 5 amperes. An amplifier to increase output potentials to 500 volts is being planned.
4.) No separate workshop is planned; this subject has been included in Low Frequency Measurement workshops. This will be treated in 1986 as part of a special publications; the next workshop is planned for 1986.

### INDUSTRIES AFFECTED

1.) Aerospace
2.) Instrument Manufacturers
3.) Electrical Utilities

### APPLICATION AND IMPACT

1.) Device phase shift and stability
2.) Power factor accuracy in power calibration
3.) Production line instrument test

### NEW REQUIREMENTS

None

### SPECIAL COMMENTS

None

## PARAMETER: MAGNETIC FIELD STRENGTH

UNITS: Gauss

### REQUIREMENTS

1.) Restore calibration service for permanent magnets.
2.) Develop capability to calibrate AC magnetic fields.

### STATUS AT NIST

1.) NIST has access to questionnaire results which will determine future direction of magnetic work.
2.) Unknown and unplanned.

A.) Unknown

### INDUSTRIES AFFECTED

1.) Nuclear Medicine
2.) Computer Magnetic Recording Industry
3.) Aerospace Industry

### APPLICATION AND IMPACT

1.) Improved product reliability
2.) Improved ability to meet specification
3.) Improved product features

### NEW REQUIREMENTS

A.) Magnetic measurement areas "such as magnetic recording media". Measurement workshops were requested. These the NIST sees as sources of input for additional needs and desires.

### SPECIAL COMMENTS

None

## SUBCOMMITTEE II: RF / MICROWAVE

### CATEGORIES

| | | |
|---|---|---|
| Antenna Gain | Impedance | Phase Noise |
| Attenuation | Microwave Power Density | Phase Shift VOR |
| Dielectric | Modulation | Power-High/Low |
| Constants | Characteristics | Pulse Rise Time |
| Field Strength | Noise Temperature | Switching Speed |
| Frequency/Time | Phase | Voltage (RF) |

### INTRODUCTION

This section of the report discusses calibration requirements for the RF/microwave industry that cannot presently be met by existing services of the National Institute for Standards and Technology (NIST) at their Boulder Laboratories. This information was originally compiled in the 1983 survey and was previously updated in 1986. It is believed that these reports were helpful in obtaining limited additional funding for NIST and new services are available. However, a wide gap continues to exist between available services at NIST and the current requirements of industry. Seven parameters as listed below are covered in detail on the following pages for several connector types and/or waveguide bands. Comments are included on the status at NIST and the impact on industry as well as calibration agencies. The second paragraph below discusses overall impact on the microwave industry.

1.) Impedance.
2.) Low/High Power.
3.) Noise Temperature.
4.) Attenuation.
5.) Phase Noise.
6.) Antenna Gain.
7.) Power Density.

### MICROWAVE TRACEABILITY PROBLEMS

Progress was made by NIST in several areas since publication of the last report but many critical problems remain unresolved. An area of major concern is calibration of standards with 3.5 mm connectors. This situation received high priority in previous versions of this report and reports by other groups on traceability problems since it concerns testing of a large share of the microwave hardware shipped by industry. Power and noise standards with 3.5 mm connectors are not presently certified in any form with proposed capabilities still several months away from implementation. NIST has recently

MICROWAVE TRACEABILITY PROBLEMS (CONTINUED)

established a service for attenuation and impedance to 18 GHz using the 7 mm six-port system with adapters and 3.5 mm calibration standards. However, this capability has not been evaluated with respect to test requirements of industry. A limitation initially exists since devices with 3.5 mm connectors can be used to 26.5 GHz. The entire microwave industry is severely hampered in development and testing of products by this deficiency. The list of programs impacted is large and includes Space Shuttle, GPS, Trident II, MILSTAR, and many special programs.

The 3.5 mm problem is far from resolution but new connector types are already slowly being used on wideband signal sources, power sensors, coaxial components, and network analyzers. Both 2.92 mm and 2.4 mm connectors are already in the field and the prospect of devices with an even smaller connector certainly exists. Planning must begin to develop capabilities for these types.

Accuracy of the services offered for 7 mm and Type N connectors is another matter for concern. The services for these interfaces have a rated accuracy that is very close to the specifications quoted for available network analyzers; this makes it impossible to establish a 4:1 accuracy ratio as request by military specifications and even measurement analysis is difficult since rated accuracies for both system and standard are very close. If calibration accuracy for the standards cannot be improved, a policy needs to be developed on an industry wide basis to resolve this problem which affects standards laboratories at all military agencies, aerospace contractors, and commercial equipment suppliers.

Lack of NIST services for WR-22 band waveguide was listed in the original report as the most serious deficiency and it was assigned top priority. Testing of hardware for the Milstar Program was being impacted by lack of calibration support. An intercomparison program was set up by several facilities as an temporary measure but NIST support is still required. Funding was received from the Department of Defense and some interim services are now available from NIST in WR-22 band from 42 to 48 GHz. Services available include attenuation, impedance, power, and antenna gain. A phase noise system has been developed that can operate in all bands where the user can provide a pair of sources. The calibration capability for thermal noise sources will be available in mid-1989. These services over a limited band will be useful but full band capability needs to be developed to support the overall needs of industry.

Also in the millimeter-wave area, the WR-15 and WR-10 bands are widely used for communications systems and short-range radars. However, the WR-10 services are limited to a narrow band when full-band services are needed to verify performance of the

MICROWAVE TRACEABILITY PROBLEMS (CONTINUED)

signal sources, analyzers, power sensors, and components used for hardware checkout. Services for WR-15 band were reasonable several years ago but have deteriorated to the point where the only identifiable capability is noise measurements over a limited range. This band is widely used by special programs so that support is badly needed for key parameters.

COMMENDATION FOR NIST PERSONNEL

This report brings attention to the very many traceability problems for the microwave industry due to lack of support capability at NIST. One fact that is often overlooked is that there are many quality people at NIST who are working diligently to resolve some of the problems described. This report attempts to generate support within the agencies of government for NIST.

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PRIORITIES

The following list provides some guidance to the priorities assigned to the parameters for this report. The highest priority is 1.) a.).

1.) Develop/Extend Capability for 3.5 mm Standards,
   a.) Impedance.
   b.) Power.
   c.) Noise Temperature.
   d.) Attenuation.
2.) Improve/Extend Capability for 7 mm Standards,
   a.) to d.) Same as Above.
3.) Develop/Extend WR-22 Band Capability (33 to 50 GHz),
   a.) Impedance.
   b.) Low Power (nominal 10 mW).
   c.) Noise Temperature.
   d.) Attenuation.
   e.) Phase Noise.
   f.) Antenna Gain.
   g.) High Power to 160 W.
4.) Develop WR-28 Band Capability for Noise Temperature (26.5 to 40.0 GHz).
5.) Develop/Improve Capability for RF Standards below 100 MHz,
   a.) Four-Terminal Resistors/Capacitors at 1,10 MHZ.
   b.) Dissipation Factors for RF Capacitors at 1,10 MHz.
   c.) Q Standards at 10 KHz to 70 MHz.
6.) Extend WR-10 Band Capability (75 to 110 GHz),
   a.) to d.) Same as 1.) Above.
7.) Develop/Extend WR-15 Band Capability (50 to 75 GHz),
   a.) to d.) Same as 1.) Above.
8.) Develop Capability for 2.92 mm and 2.4 mm Standards,
   a.) to d.) Same as 1.) Above.
9.) Develop High Power Capability for 0.1 to 200 W at 10 MHz to 6 GHz.
10.) Develop High Power Capability at 1 MHz to 2 GHz for Levels Up to 25 kW.
11.) Develop Capability for Power Density to 100 mW/sq cm at 300 MHz to 26.5 GHz.

PARAMETER: IMPEDANCE/QUALITY FACTORS

UNITS: Magnitude - Ohms or Ratio, Phase - Degrees

REQUIREMENTS

1.) Complete measurement capability for one and two port 3.5 mm impedance standards so that total frequency range is 0.1 to 26.5 GHz. Reflection coefficient range is 0.01 to 1.0 with a basic accuracy of +/- 0.002 to 0.01. Phase accuracy is +-1.0 to 3.0 degrees (magnitude > 0.05).
2.) Extend measurement capability for one and two port impedance standards in WR-22 band over full range of 33 to 50 GHz with a reflection coefficient range of 0.002 to 1.0 and a basic accuracy of +/-0.001 to 0.005.
3.) RF standards operating below 100 MHz need the following:
    a.) Establish calibration capability for four-terminal resistance and capacitance standards at 1 to 15 MHz. Resistance range is 0.1 ohms to 10K ohms with an accuracy of +/-0.05 to 1.00 %. Capacitance range is 1 to 1000 pF with an accuracy of +/- 0.05 to 0.10 %.
    b.) Develop capability to evaluate dissipation factors at 1 and 10 MHz for capacitors ranging from 1 to 1000 pf.
    c.) Improve accuracy for Q standard calibration. Frequency range is 10 KHz to 70 MHz with an indicated Q of 5 to 1000 and a needed accuracy of +-3 to 5 %. A new NIST technical note showing methods to apply data would be helpful.
4.) Extend capability for WR-10 band to full range from 75 to 110 GHz. Reflection coefficient range is 0.002 to 1.0 with accuracy from +/- 0.005 to 0.01.
5.) Reestablish capability for WR-15 band at 50 to 75 GHz. Range and accuracy similar to 2.).

STATUS at NIST

1.) Limited capability is available. Devices are measured to 18 GHz on the 7 mm six-port system; uncertainties have not been evaluated with respect to industry requirements. Capability to 26.5 GHz is expected in 1989.
2.) Capability is available for measurements at 42 to 48 GHz on interim manual system. A full-band automated system is now in development.

PARAMETER: IMPEDANCE/QUALITY FACTORS (CONTINUED)

STATUS at NIST (CONTINUED)

3.) No capability is available for four-terminal standards or for dissipation readings on RF capacitors and there are no plans to develop these capabilities. Capability is available for Q standards at reduced accuracy.
4.) No plans to extend range of WR-10 services.
5.) No plans to reestablish WR-15 services.
A.) Capability is available for 7 mm connectors but accuracy is not adequate to check microwave network analyzers with specified accuracy of 4:1 or by measurement analysis. Improved accuracy is needed or policy formulated using alternative means.
B.) No capability for 2.92 mm connectors and no plans.
C.) No capability for 2.4 mm connectors and no plans.

INDUSTRIES AFFECTED

1.) Department of Defense.
2.) Aerospace Industry.
3.) Instrument manufacturers.
4.) Component Manufacturers.

APPLICATION AND IMPACT

1.) It is estimated that more than 200 automatic network analyzers are now in operation to test the wide variety of microwave hardware being produced by industry. Most devices have SMA connectors so that they are tested in a 3.5 mm environment to achieve optimum results. Manufacturers of network analyzers offer verification procedures as a first-order accuracy test but standards are not available to confirm accuracies as shown on specification sheets for the 3.5 mm interface. The entire industry is affected including programs such as Space Shuttle, GPS, Trident II, MILSTAR, and special programs.
2.) Extended capability in WR-22 band is required to support the MILSTAR Program Uplink System and developmental efforts. Most commercial instrumentation is full band.
3.) Four-terminals bridges, Q meters, and similar equipment are used to maintain quality control on RF components by both manufacturers and users. In many cases, testing to military specification is performed. It is not possible to verify measuring systems without NIST support.

PARAMETER: IMPEDANCE/QUALITY FACTORS (CONTINUED)

APPLICATION AND IMPACT (CONTINUED)

4.) The WR-10 band is used for seekers, short-range radars, and guidance systems as well as special programs. The STARTLE Program is a typical effort.
5.) The WR-15 band is used by many special programs.

PARAMETER: IMPEDANCE/QUALITY FACTORS (CONTINUED)

NEW REQUIREMENTS

A.) Improve measurement accuracy at 0.1 to 18 GHz for one and two port 7 mm impedance standards. Reflection coefficient range is 0.005 to 1.0 with basic accuracy of +/- 0.001 to 0.01. Phase accuracy is +/- 0.3 to 3.0 degrees (magnitude > 0.05). This capability is needed to test analyzers per requirements of MIL-STD-45662.

B.) Develop support capabilities for 2.92 mm connectors. Ranges and accuracies will be similar to 1.) above except maximum frequency is 40 GHz. Capability will support development of broadband systems and systems in the millimeter-wave range.

C.) Develop support capabilities for 2.4 mm connectors. Ranges and accuracies will be similar to B.) above except maximum frequency is 50 GHz. Capability will support development of broadband systems and systems in the millimeter-wave range.

SPECIAL COMMENTS

1.) Standards used for the MILSTAR Program intercomparison plan in WR-22 band were recently submitted to NIST for testing over the available range. Test results will be compiled and evaluated with respect to program requirements.

2.) Dimensional analysis of microwave components is currently being performed by several facilities using NIST technical notes prepared several years ago. Revised notes showing the latest information would be useful.

PARAMETER: LOW/HIGH POWER

UNITS: Watts

REQUIREMENTS

1.) Provide effective efficiency and calibration factor data for 3.5 mm power sensors from 10 MHz to 26.5 GHz at nominal power levels from 0.1 to 100 mW with expected accuracy of +/-0.5 to 1.5 %.
2.) Provide effective efficiency and calibration factor data for thermistor mounts and calorimeters in WR-22 band at 33 to 50 GHz. Nominal power range is 1 to 100 mW with an accuracy of +/- 1.0 to 2.0%.
3.) Develop capability for high-power measurements in WR-22 band. Frequency range is 43.5 to 45.5 GHz for power to 160 Watts with an accuracy of +/- 5.0%.
4.) Extend capability for WR-10 band so that it covers full band from 75 to 110 GHz with range and accuracy similar to 2.). Adapt system to allow calibration of calorimeters.
5.) Rebuild capability for WR-15 band at 50 to 75 GHz. Nominal power is 1 to 100 mW with accuracy of +/- 1.5 to 2.5%.
6.) Extend the power range down to 0.1 nW for Type N and 3.5 mm devices over a frequency range of 10 MHz to 18 GHz (N) or 26.5 GHz (3.5). The required accuracy is +/- 0.5 to 2.0%.
7.) Establish capability for power standards operating at levels from 0.1 to 200 W between 10 MHz and 18 GHz. Required accuracy is +/- 1.0 to 5.0%.
8.) Establish a capability for type N power standards from 0.1 mW to 1000 W over a frequency range of 10 MHz to 1.6 GHz. The required accuracy is +/- 1.0 to 3.0%.
9.) Establish a capability for type N power standards from 100 mW to 25 KW over a frequency range of 1 MHz to 2 GHz. The required accuracy is +/- 0.5 to 2.0%.

STATUS at NIST

1.) Effort is in process to adapt 7 mm and WR-42 systems to meet requirements.
2.) Interim service to 46 GHz is presently now available using a calorimeter that has been characterized in WR-28 band and the efficiency data extrapolated into WR-22 band. A full-band standard is under development.
3.) Capability was recently developed to meet this requirement but the user must provide high-power signal source.

PARAMETER: LOW/HIGH POWER (CONTINUED)

STATUS at NIST (CONTINUED)

4.) No plans at the present time to extend capability over full band. Calibration of calorimeters is under investigation.
5.) It is expected that WR-15 system will be available with the requested accuracy by the end of 1989.
6.) No capability for low-level measurements and no plans.
7.) No capability for high-power measurements and no plans.
8.) Same as 7.) above.
9.) Same as 7.) above.
A.) No capability for 2.4 mm connectors and no plans.

INDUSTRIES AFFECTED

1.) Department of Defense.
2.) Aerospace Industry.
3.) Instrument Manufacturers.

APPLICATION and IMPACT

1.) Working power standards with 3.5 mm connectors are used to test a large share of the microwave instruments now being delivered and a majority of the hardware used on defense programs. Since capability does not exists at NIST for this connector type, calibration must be performed against 7 mm coaxial and waveguide standards. This technique is very time consuming so that few facilities can justify the effort. Lack of standards of this type affects manufacturers of microwave equipment, communications companies, and defense efforts such as GPS, MILSTAR, and Trident II.
2.) Development of a full band, precise calibration capability for WR-22 band is required to support the MILSTAR Program Uplink System and developmental efforts.
3.) The Navy is developing shipboard, submarine, and shore terminals to work with MILSTAR Communications Satellites. Operation of the Uplink System requires that the terminals have transmitters producing up to 160 W at 43.5 to 45.5 GHz.
4.) Special programs have already developed or are currently designing systems at 75 to 110 GHz. This range is used for short range radars and guidance systems.
5.) Many special programs use the WR-15 band for communications so that support is required to measure output levels from several types of microwave sources.

PARAMETER: LOW/HIGH POWER (CONTINUED)

APPLICATION AND IMPACT (CONTINUED)

6.) Support to the GPS Systems requires calibration at the 1 nW level. Many instruments, such as spectrum analyzers, use low-level standards to establish a reference on the display. Accurate setup of this reference requires a precision sensor operating in the -10 to -60 dBm range.

7.) Microwave communication systems use high-level sources rated from 0.1 to 200 W at frequencies to 6 GHz. Telemetry systems designed for the Trident I and II Programs use transmitters in this range that must be checked to program requirements. Failure to have accurate standards has caused disputes with suppliers.

8.) Support to the TACAMO program requires high-power calibration to frequencies in the UHF range.

9.) Checkout and alignment of high-power transmitters for military navigation and surveillance requires power standards capable of measuring levels up to 25 KW. Support of tactical air and ground communication gear requires RF power measurement capability from 100 mW to 1000 watts.

NEW REQUIREMENTS

A.) Provide effective efficiency and calibration factor data for 2.4 mm power sensors from 50 MHz to 50 GHz at nominal power levels from 0.1 to 100 mW with expected accuracy of +/- 0.8 to 2.5%. These sensors are being used for broadband systems and systems in the millimeter-wave range.

SPECIAL COMMENTS

None.

PARAMETER: NOISE TEMPERATURE

UNITS: dB or K

REQUIREMENTS

1.) Complete service for both gas-discharge and solid-state noise standards in WR-22 band at 33.0 to 50.0 GHz. Nominal ENR range is 15 to 17 dB with an expected accuracy of +/- 0.15 dB.
2.) Establish service for solid-state coaxial noise sources with 3.5 mm connectors over range of 10 MHz to 26.5 GHz. Nominal ENR range is 12 to 18 dB with expected accuracies from +/- 0.05 to 0.30 dB.
3.) Extend service for solid-state coaxial noise sources with 7 mm connectors so that total range is 10 MHz to 18 GHz. Nominal ENR range is 4 to 30 dB with expected accuracies from +/- 0.05 to 0.20 dB.
4.) Establish service for noise sources in WR-28 band at 26.5 to 40 GHz. Nominal values and accuracies are same as 1.) above.

STATUS at NIST

1.) A service for WR-22 band has been under development over the past two years. Tentative ranges and accuracies only have been published. Service will be available in the middle of 1989.
2.) Services are not available for 3.5 mm devices and there is no known date for start of services.
3.) Service was recently extended to 12 GHz. Capability to 18 GHz may be available in 1990.
4.) No service is available and there is no known date for start of services.

INDUSTRIES AFFECTED

1.) Department of Defense.
2.) Aerospace Industry.
3.) Instrument Manufacturers.

APPLICATION AND IMPACT

1.) The Uplink System for the MILSTAR Program and developmental efforts require support in WR-22 band.
2.) Noise standards with 3.5 mm connectors are not available to support testing of the large volume of low-noise amplifiers, mixers, and systems used for communications and similar applications. The

PARAMETER: NOISE TEMPERATURE (CONTINUED)

APPLICATION AND IMPACT (CONTINUED)

development of MMIC also uses standards of this type.

3.) Calibration laboratories at military, aerospace, and industrial facilities are required to support 7 mm standards over the total range to 18 GHz but no NIST support exists above 12 GHz.

4.) Capability is required in the WR-28 band to support development of weapons systems and other special programs.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

Previously requested service for gas-discharge and solid-state noise standards in WR-42 band at 18.0 to 26.5 GHz is expected to be available in early 1989. Nominal ENR range is 15 to 17 dB with expected accuracy of +/- 0.10 dB.

PARAMETER: ATTENUATION

UNITS: dB

REQUIREMENTS

1.) Complete calibration services for 3.5 mm attenuators so that the frequency range is 0.1 to 26.5 GHz, attenuation range is 0 to 60 dB, and measurement uncertainties vary from +/- 0.02 to 0.1 dB.
2.) Extend service for attenuators in WR-22 band over full range of 33 to 50 GHz with a measurement range of 0 to 60 dB and a basic accuracy of +/- 0.002 to 0.1 dB.
3.) Extend capability for WR-10 band to full range from 75 to 110 GHz. Range to 50 dB with accuracy of +/- 0.01 to 0.2 dB.
4.) Reestablish capability for WR-15 band at 50 to 75 GHz. Range to 60 dB with accuracy of +/- 0.004 to 0.1 dB.

STATUS at NBS

1.) Limited capability is available. Devices are measured to 18 GHz on the 7 mm six-port system; uncertainties have not been evaluated with respect to industry requirements. Capability to 26.5 GHz is expected in 1989.
2.) Capability is available for measurements at 42 to 48 GHz on interim manual system. A full-band automated system is now in development.
3.) No plans to extend range of WR-10 services.
4.) No plans to reestablish WR-15 services.
A.) Capability is available for 7 mm connectors but accuracy is not adequate to check microwave network analyzers with specified accuracy of 4:1 or by measurement analysis. Improved accuracy is needed or policy formulated using alternate means.
B.) Service for 30 MHz attenuators has been discontinued during construction of new facility with improved capability.
C.) Unknown. New facility may have this capability.

INDUSTRIES AFFECTED

1.) Department of Defense.
2.) Aerospace Industry.

PARAMETER: ATTENUATION (CONTINUED)

APPLICATION and IMPACT

1.) More than 200 automatic network analyzers are now in use to test a large share of the microwave hardware being delivered. Adequate standards are not available to verify performance at the 3.5 mm interface. This affects the entire industry from manufacturers to defense programs.
2.) The Uplink System of the MILSTAR Program requires support in WR-22 band.
3.) The WR-10 band is used for seekers, short-range radar, and guidance systems as well as special programs. The STARTLE Program is a typical effort in this band.
4.) The WR-15 band is used by many key special programs.

NEW REQUIREMENTS

A.) Improve capability at 0.1 to 18.0 GHz for calibration of 7 mm attenuation standards. Magnitude range is 0 to 60 dB with a basic accuracy of +/- 0.005 to 0.1 dB. Phase accuracy is +/- 0.05 to 1.0 degrees. Required to support the calibration of network analyzers per MIL-STD-45662A.
B.) Improve measurement accuracy at 30 MHz for piston attenuators from +/- 0.003 to 0.005 dB per 10 dB to +/- 0.0002 dB per 10 dB. Required range is 120 dB. This improvement is necessary to support the new generation of measurement receivers now in widespread use by industry and by defense programs.
C.) Establish capability at 21.4 MHz to support the CASS program. Required range is 120 dB and requested accuracy is +/- 0.0005 dB per 10 dB.

SPECIAL COMMENTS

The 30 MHz capability at NIST will be out of service until late 1989. Emergency services can be obtained from NPL in England.

PARAMETER: PHASE NOISE

UNITS: dBc/Hz

REQUIREMENTS

1.) Calibrate phase-noise reference standards as needed to support the six frequency ranges used by MILSTAR Program. Offsets and levels are as follows:

CARRIER FREQUENCY

| OFFSET Hz | 5 MHz | 65 - 80 MHz | 1.3-1.4 GHz | 6.4-7.5 GHz | 20.5-22.5 GHz | 42.5-46.5 GHz |
|---|---|---|---|---|---|---|
| 1 | -112 | | | | | |
| 10 | -125 | | | | | |
| 100 | -145 | -95 | -88 | -70 | -65 | -59 |
| 1K | -155 | -105 | -100 | -80 | -77 | -71 |
| 10K | -165 | -115 | -110 | -93 | -87 | -81 |
| 100K | | -130 | -115 | -113 | -112 | -86 |
| 1M | | -130 | -135 | -120 | -131 | -106 |
| 10M | | -130 | -135 | -120 | -131 | - 106 |
| 100M | | | -135 | -120 | -131 | -106 |
| 1G | | | | -120 | -131 | -106 |

Note: The negative figures in the table represent the phase noise component defined in terms of decibels below carrier level in a 1 Hertz measurement bandwidth. Abbreviated as dBc/Hz.

STATUS at NIST

1.) A measurement system has been developed with an accuracy better than +/- 1 dB for offsets from 1 Hz to 1 GHz depending on carrier frequency. Reference sources are available to 8 GHz. User must provide two sources for other ranges. Additional development work in process.

A.) Systems developed for MILSTAR Program can be used over broad ranges. Noise floor and offset limits are not published.

INDUSTRIES AFFECTED

1.) Department of Defense.
2.) Aerospace Industry.

PARAMETER: PHASE NOISE (CONTINUED)

APPLICATION and IMPACT

1.) The following MILSTAR Program systems require this support:

| | |
|---|---|
| 5 MHz: | Airborne Terminal and Payload Master Oscillators. |
| 70 - 80 MHz: | Airborne Terminal Local Oscillator. |
| 1.3 - 1.4 GHz: | Airborne Terminal System. |
| 6.4 - 7.5 GHz: | Airborne Terminal System. |
| 20.5 - 22.5 GHz: | Downlink System. |
| 42.5 - 46.5 GHz: | Uplink System - Shipboard, Submarine, Shore Terminals. |

NEW REQUIREMENTS

A.) Develop capability to measure SSB phase noise over broad ranges for low-noise sources of several types. Capability would be equal to or better than limits specified for MILSTAR Program. This service would provide calibration laboratories with accurate references for testing frequency synthesizers and similar equipment.

SPECIAL COMMENTS

None.

PARAMETER: ANTENNA GAIN

UNITS: dB

REQUIREMENTS

1.) Develop capability for a WR-22 band service at 33 to 50 GHz. Nominal value would be 24 dB with an accuracy of +/- 0.1 dB. Critical frequency was listed as 44.5 +/- 2.0 GHz.

STATUS at NIST

1.) Capability has been developed in WR-22 band for 42-46 GHz with an accuracy of +/- 0.14 dB. Additional work in process.

INDUSTRIES AFFECTED

1.) Department of Defense.
2.) Aerospace Industry.

APPLICATION and IMPACT

1.) Support was required in WR-22 band to support Uplink System of the MILSTAR Program. Contractors were directed by the DoD to develop standards for antenna gain measurements.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) Requirement for WR-22 service has been largely satisfied. Further needs of industry are being investigated.
2.) NIST capability is additionally available for a limited range in WR-15 band.

PARAMETER: POWER DENSITY

UNITS: watts/area

REQUIREMENTS

1.) Develop capability to calibrate the probes used in monitoring radiation over the frequency range of 100 kHz to 26.5 GHz. Power density range is from 0.1 to 100 mW/sq cm with an accuracy of +/- 0.5 dB.

STATUS at NIST

1.) A calibration service exists for 0.2 to 18 GHz. Power density range and accuracy are not specified in calibration services bulletin.

INDUSTRIES AFFECTED

1.) Military calibration agencies.
2.) Private sector.

APPLICATION and IMPACT

1.) OSHA regulations make it necessary to verify that microwave radiation levels in work areas are safe, e.g. radar antenna system radiation pattern at the antenna test sites and on shipboard.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

None.

## SUBCOMMITTEE III: ELECTRO - OPTICS

### CATEGORIES

Radiometry/Photometry Technology
Laser Technology
Fiber Optic System Technology

### INTRODUCTION

Since the original report was prepared in 1982, this subcommittee has been reorganized. Some of the former committee members are still active with this requirement activity and are therefore listed as such. In addition, new members have been added.

The following pages show the committee's concern in regard to the three groups of Radiometry/Photometry Technology, Laser Technology, and Fiber Optics System Technology. All parameters are listed in alphabetical order within each of the three groups. Within each parameter, the requirements are listed in order of priority.

Overall, there are several critical parameters that industry is pushing for near term action or solution. Clearly not all can be given equal attention by the NIST but perhaps alternate solutions and/or recommendations can be proposed by the NIST (certifying an industrial or university laboratory for specific items, e.g. Bennett's at China Lake for diffuse reflectance standards).

Classifying the provided parameters by priority turned out to be an impossible task. Due to the diverse background of the subcommittee members, too many different projects were considered important for different reasons. There remained three items, however, that warrant further emphasis in terms of priority:

1.) Ambient and Cryogenic Blackbodies,
Because of the exploding demand in electro-optics as well as precision thermometry, high accuracy blackbodies are required for several temperature ranges. Support by the NIST in this area is considered essential.



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INTRODUCTION (CONTINUED)

2.) Laser Beam Profile,
The need for exact beam profile measurements has become apparent for application in programs such as laser fusion, material science, and aerospace. An increased effort by the NIST in this area is recommended very highly.

3.) Fiber Optic Power Meters,
The availability of high accuracy fiber optic power meters is required for almost all industries utilizing lasers of various nature. Results of the round robin and perhaps other (future) such programs should be utilized to recommend better instruments and standards.

UPDATED COST IMPACTS and PRIORITIES

Improving the calibration accuracies for fiber optic power measurements will allow fiber optic communication system designers to reduce the power budgets in fiber optic systems. This would save money by allowing for more efficient systems and reducing the robustness of designs and thus the amount and cost of hardware. This improvement in efficiency and reduction in hardware costs in turn benefits the consumer by lowering the costs of fiber optic communication systems.

Improved fiber optic power calibration accuracies will also allow better system monitoring. Maintenance costs will be reduced since good fiber optic sources (laser diodes and LEDs) won't be replaced too soon and down time can be reduced due to sources failing sooner than expected.

Currently there are no NIST calibration services for OTDR attenuation (power) or length measurements available to industry. The NIST is working to provide an OTDR calibration service. What is required is an economical service or easy to use standard to support OTDRs as outlined in this report.

Transfer standards in general are of high priority. Work is required on technology for the practical transfer of national standards from the NIST to standard laboratories in industry and government. These transfer standards should also be developed with economy and ease of use in mind. In the past, much work at the NIST has been put into improving the national measurement capability, but not much into transferring that measurement to standard laboratories with ease and economy. One example of the NIST providing a transfer standard with these requirements in mind is the Detector Transfer Response Intercomparison Package (DTRIP). But even this standard is now old and in need of replacement.

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PARAMETER: AMBIENT BACKGROUND BLACKBODY

UNITS: Kelvin (K)

REQUIREMENTS

1.) Radiance temperature from 200 to 1200 K with accuracies of +/- 0.02 K for 200 to 400 K and +/- 0.05 K for temperatures > 400 K. Ambient background.
2.) Temperature difference from 278 to 318 K with accuracy of + 0.1%.

STATUS at NIST

1.) Capability exists from ambient to 1200 K,
a.) -40 to +40 degrees C +/- 0.2 degrees C abs., +/- 0.05 degrees C temperature difference. (True Ambient Blackbody)
b.) Ambient to gold point +/- 0.5 to 1.0% radiance for specified wavelength, lambda. (Spectral Radiance)

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.

APPLICATION and IMPACT

1.) Radiation source for testing IR devices such as Imagers and Forward Looking Infrared Systems (FLIRS).
2.) Research and defense related programs.

NEW REQUIREMENTS

1.) Blackbody spectral distribution.

SPECIAL COMMENTS

1.) Eventually accuracies of +/- 0.005 K are required for radiance temperature measurements.

PARAMETER: CRYOGENIC BACKGROUND BLACKBODY

UNITS: Kelvin (K)

REQUIREMENTS

1.) Radiance temperature (20 K and 77 K background) from 100 to 500 K with accuracy of < 1.0 K.

STATUS AT NIST

1.) Will be reestablished in the future (budget has been approved, several years for construction and implementation are required).

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.

APPLICATION and IMPACT

1.) IR radiation source for testing IR detecting/imaging devices.
2.) Research and defense related programs.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) While constructing the in-house capability, NIST is investigating the use of alternate facilities to be utilized by NIST personnel in support of industry and government agencies needs.

PARAMETER: DETECTOR SPECTRAL RESPONSE

UNITS: Absolute Responsivity (Amperes/Watt)

REQUIREMENTS

1.) Silicon detector absolute response (A/W) for 200 to 1064 nm with accuracy of < 5.0%.
2.) Better accuracy from 1.0 to 1.6 um ( + 1.0%)
3.) Better accuracy for 10.6 um ( + 1.0%)
4.) Power measurements up to 6 mW for the mercury lines of 254 and 365 nm.

STATUS AT NIST

1.) Detector Transfer Response Intercomparison Package (DTRIP):

| Wavelength | Accuracy | Wavelength | Accuracy |
|---|---|---|---|
| 250-390 nm | + 6.0% | 860-960 nm | +/- 2.2% |
| 400-490 nm | + 1.9% | 1014 nm | +/- 5.9% |
| 500-850 nm | + 0.8% | 1064 nm | +/- 5.7% |

2.) NIST can calibrate detectors at 1300 nm and 1550 nm with accuracy of + 1.0%.
3.) Unknown.
4.) Unknown.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Fiber Optics Communications Industry.

APPLICATION and IMPACT

1.) Laser Power Measurements - UV, Visible, IR.
2.) Radiometric Measurements.
3.) Fiber Optics.

NEW REQUIREMENTS

1.) Better accuracy from 250-390 nm.
2.) Better accuracy at 1014 nm and 1064 nm.
3.) Calibration of Ge detectors from 800-1700 nm at 10 nm intervals accuracy +/- 2.0%.

PARAMETER: DETECTOR SPECTRAL RESPONSE (CONTINUED)

SPECIAL COMMENTS

None.

PARAMETER: FTIR SPECTROPHOTOMETER PHOTOMETRIC SCALE CALIBRATION STANDARDS

UNITS: Percent Transmission

REQUIREMENTS

1.) Percent transmission for wavelength (lambda) = 1 to 40 um, range 0 to 100% transmission, accuracy < 1.0%.

STATUS at NIST

1.) Development work for two systems are in progress for 2 to 25 um with accuracies of 1 to 3%.

a.) Dispersive system: Will provide benchmarks up to 50 um.
b.) FTIR system: Will be operating in the scanning mode for up to 25 um.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Biological Industry.
3.) Chemical Industry.
4.) Department of Defense.
5.) Forensic Medical Industry.

APPLICATION and IMPACT

1.) Determining infrared absorption transmission characteristics of various substances and optical components.
2.) Test and characterization of IR components such as Ge, Si lenses, etc..
3.) Research related programs - optical components.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) Possible use of neutral density filters as SRM's. Various materials under investigation by NIST personnel.

PARAMETER: IR WINDOW and FILTER TRANSMISSION

UNITS: Percent Transmission

REQUIREMENTS

1.) Percent transmission (measurement, environment 20 to 300 K) in the range of 0 to 100% transmission, % transmission accuracy 1.0%T for lambda 1 to 40 um.

STATUS at NIST

1.) Research in progress. One to one and a half (1 to 1 1/2) years before implementation.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Defense.

APPLICATION and IMPACT

1.) Component testing of optical test systems for IR sensors/detectors such as lenses, etc.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

None.

PARAMETER: REFLECTANCE (DIFFUSE)

UNITS: Ratio

REQUIREMENTS

1.) Diffuse Reflectance Standards for 1.06 um (Nd:YAG) and 10.6 um (CO2) at accuracies of +/- 1.0%.

STATUS at NIST

1.) Unknown.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.

APPLICATION and IMPACT

1.) Light Detecting and Ranging (LIDAR).
2.) Material Surface Analysis.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) Flame sprayed Aluminum is not stable enough. Require a real standard. Research available in the commercial sector.

PARAMETER: REFLECTANCE (SPECULAR)

UNITS: Ratio

REQUIREMENTS

1.) Specular reflectance for 0.27 to 30 um with an accuracy of +/- 0.001 reflectance units.

STATUS at NIST

1.) Research in progress. One to one and a half (1 to 1 1/2) years before implementation.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Material Science Industry.

APPLICATION and IMPACT

1.) Optical component testing.
2.) Light Detecting and Ranging (LIDAR).
3.) Material Property Analysis.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) Specular Reflectance to at least 10.6 um (CO2) required at specific angles of incidence/reflection. Combine with current NIST effort on "Scratch and Dig" samples for surface texture.

PARAMETER: LASER BEAM PROFILE

UNITS: Power Density Ratio

REQUIREMENTS

1.) Laser profile characteristics for all ranges. National Standards are required for both beam uniformity and divergence measurements. All mode properties of the beam need to be measured.

STATUS at NIST

1.) Some work is being conducted primarily at 1.064 and 10.6 um. NIST has promised laser beam profile standards and measurement service contingent on funding.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Laser Fusion Research.
4.) Material Science Industry.
5.) Manufacturing, etc.,
Almost all users of lasers could benefit from this.

APPLICATION and IMPACT

1.) Pulsed Laser profiles - beam shaping.
2.) Measurements are critical to both strategic and tactical laser device performance. Development of national standards and uniform techniques could save program development costs.
3.) Critical to communication application for information fidelity.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) Phase information combined with profiles can be used to extract mode content. Some commercial work is being done in this area, e.g. Spiricon, Zygo, Wyco.

PARAMETER: LASER MODE EVALUATION

UNITS: Ratio

REQUIREMENTS

1.) Mode (TEM) for all ranges but especially at 1.064 and 10.6 um at high accuracies. (See page 15 also.)

STATUS at NIST

1.) Some work in conjunction with profile measurements has been undertaken.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Fiber Optic Test Equipment Industry.
4.) Medical Industry.
5.) Optical Fiber Communication Industry.

APPLICATION and IMPACT

1.) Knowledge of Mode Structure is necessary for prediction of power density in focused beam and power profile in the focal plane. Mode structure determines the fraction of launched power captured by an optical fiber.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) Simple power measurement is insufficient to know what mode a laser or laser diode is in.

PARAMETER: LASER POWER/ENERGY

UNITS: Watts/Joules

REQUIREMENTS

1.) Lasers/Wavelengths - Ultraviolet (ArF at 193 nm) to 15 microns; (Nd:YAG, 1.064 microns; DF,3.5-3.8 microns; CO2, 10.6 microns; tunable infrared laser system 2-15 microns).
2.) Laser Power/Energy - from near photon limit of 10-17 joules at 1.064 microns to multi-kilojoule (pulsed) and megawatt (CW).

At low and moderate energies the required accuracies are:

| Wavelength | Energy | Accuracy |
|---|---|---|
| 1.064 microns | 0.1-10. femtojoules | +/- 3.0% |
| 1.064 microns | 1.0 nanojoules | +/- 3.0% |

3.) Energy calibrations at 400 nm with calibration accuracies of less or equal to +/- 3.0% from 1 to 10 mjoules.
4.) Establishing semiconductor wavelengths standards in the bands interesting for fiber optics application; 700-900 and 1300-1550 nm.

The accuracy of transfer standards should be approximately +0.2% below 1 u watt.

STATUS at NIST

1.) NIST is working on a broad spectrum of standards between 10-9 and 103 joules/pulse covering the 0.25 to 15 micron spectral range. It is unclear when these will become available. Calibration support in UV and IR is "hampered" by the fact that at present the lasers in the calibration system cover the visible, 1.064 microns, and 10.6 microns. NIST has no power/energy calibration facility in the UV or in the IR range away from Nd:YAG and carbon dioxide.
2.) Transfer standard characterized to 5 kilowatts at 10.6 microns exists and can be characterized at 1.06 microns at high power if requests are made directly to NIST. One femtojoule transfer standards are available at 1.06 microns. Accuracies of +/- 3.0% are available at 1.064 microns from 10 mjoules to 1

PARAMETER: LASER POWER/ENERGY (CONTINUED)

STATUS at NIST (CONTINUED)

joule. Below 10 mjoules accuracies of +/- 5.0% are available.
3.) Unknown.
4.) Unknown.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Agriculture Industry.
3.) Civil Engineering.
4.) Department of Defense.
5.) Machining.
6.) Medical Industry.
7.) Laser Fusion Research.

APPLICATION and IMPACT

1.) Laser applications are becoming much more common and hence the need for calibration support is rapidly growing. The experience NIST has gained should be shared with the measurement community in order to minimize errors and to limit duplication of much of the effort that has already been expended.
2.) Laser welding reliability and cutting accuracy suffer if power measurements are inaccurate. Surgical applications require known power levels. Power/energy at any frequency need to be traceable to National Standards.
3.) Accuracies at low energy levels are required for laser tracking and laser target acquisition.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) NIST needs to develop broader and more flexible wavelength coverage in power/energy calibration and to extend the scale at both the low and the high power/energy end.
2.) In the future the wavelength range should be continuous from 0.19 to 25 microns.

PARAMETER: LASER ATTENUATION

UNITS: Ratio

REQUIREMENTS

1.) Large value of attenuation standards analogous to RF step attenuators; 0-70 dB +/- 0.5 dB.

STATUS at NIST

1.) NIST has initiated work in using laser heterodyning techniques to measure large optical attenuation values.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Test and Measurement.

APPLICATION and IMPACT

1.) Ability to put known loss into laser system.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

None.

PARAMETER: LASER POINTING and TRACKING

UNITS: Radians

REQUIREMENTS

1.) Angle range: 1-10 microradians.
Imprecision +/-0.3 microradians.
Resolution 0.1 microradians.

10-100 microradians.
Imprecision +/- 3.0 microradians.
Resolution 1.0 microradian.

STATUS at NIST

1.) Unknown.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Communication Industry.
3.) Department of Defense.

APPLICATION and IMPACT

1.) Pointing and tracking of communication satellites. Define the angles of Laser/Fiber gyroscopes (ring type).

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

None.

PARAMETER: OPTICAL FIBER CHARACTERISTICS

REQUIREMENTS

1.) Chromatic Dispersion (single mode).
2.) Development of fiber optic connector characterization.
3.) Near and far field pattern (numerical aperture).

STATUS at NIST

1.) Unknown. Report in progress.
2.) Unknown. Report in progress.
3.) Unknown. Report in progress.

INDUSTRIES AFFECTED:

1.) Aerospace Industry.
2.) Department of Defense.
3.) Telecommunications Industry.

APPLICATION and IMPACT

1.) Test and calibration of fiber optic test equipment.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

None.

PARAMETER: OPTICAL POWER METERS

UNITS: Watts, Joules

REQUIREMENTS

1.) Calibration of single mode and multimode optical fiber power meters in all three optical fiber "windows" (850, 1300, and 1550 nm) from 0.01 nW to 100 mW at + 1.0% accuracy.

STATUS at NIST

1.) NIST has some capability of 850 nm (multimode), and 1300 and 1550 nm (single mode) optical power meter calibration.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Telecommunications Industry.

APPLICATION and IMPACT

1.) Test, evaluation, and calibration of optical power meters used in the design, manufacture, and maintenance of fiber-optic data and communication systems.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) The results of a round robin test conducted by NIST indicated an unreasonably large variation in power meter readings taken at different laboratories.
2.) NIST will not provide total uncertainty with report of calibration for power at 1300 and 1550 nm wavelengths.
3.) Standardized method for calibration of optical power meters and detectors is required; defining light source wavelength, bandwidth of < 10 nm, and type of coupling to the detector such as fiber core 50 um dia.

PARAMETER: OPTICAL POWER METERS (CONTINUED)

SPECIAL COMMENTS (CONTINUED)

4.) Calibration of power meters and detector standards should be at stated power levels from > 10 uW to < 100 uW with 100 uW preferred.

PARAMETER: OPTICAL TIME DOMAIN REFLECTOMETER CALIBRATION (OTDR)

UNITS: Length (meters), Attenuation (dB)

REQUIREMENTS

1.) Calibration for both single mode and multimode long-haul and local area network OTDR's.

| | |
|---|---|
| Length accuracy | - 1 meter |
| Attenuation range | - 0 to 30 dB |
| Attenuation accuracy | - + 0.04 dB from 0 to 10 dB |
| | + 0.08 dB from 10 to 30 dB |

STATUS at NIST

1.) NIST provided the military with a standard reference fiber for OTDR calibrations. However, at this time they cannot provide any calibration services for industry.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Telecommunications Industry.

APPLICATION and IMPACT

1.) Test, evaluation, and calibration of OTDR's.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

None.

PARAMETER: DETECTOR SPECTRAL RESPONSE
(Fiber Optic Communications Use)

UNITS: Absolute Responsivity (Amperes/Watt)

REQUIREMENTS

1.) Detector absolute response (A/W) for 850 nm, 1300 nm, and 1550 nm with accuracies of + 1.0%.

STATUS at NIST

1.) NIST has a Si detector transfer response intercomparison package (DTRIP) with uncertainty of +/- 0.8% at 850 nm. In addition, NIST can calibrate Ge detectors at 1300 nm and 1550 nm with an accuracy of approximately +/- 1.0%.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Fiber Optic Communication Industry.

APPLICATION and IMPACT

1.) Test, evaluation, and calibration of fiber optic test equipment.
2.) Correlation of U.S. and foreign optical communication power measurements.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) NIST furnished a T.E. cooled detector and electronics package with data (such as the DRIPT package) would be useful for the 1300 nm and 1550 nm wavelengths.
2.) NIST should instigate the development of a standardized procedure for fiber optic power meter calibrations. In this way all the calibration laboratories can use the same measurement methods.

PARAMETER: FIBER OPTIC ATTENUATORS

UNITS: dB

REQUIREMENTS

1.) Calibration of N.D. filter and wedge type Fiber Optical Attenuators at 850, 1300, and 1550 nm in 10 dB steps from 0 to 60 dB. Accuracies of +/- 0.1 dB.
2.) Calibration of variable Fiber Optic Attenuators in the range of 0-80 dB at 850 nm, 0-70 dB at 1300 nm, and 0-50 at 1550 nm. Accuracies of +/- 0.1 dB/10 dB step and resolution of 0.01 dB.

STATUS at NIST

1.) Unknown.
2.) Unknown.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Telecommunications Industry.

APPLICATION and IMPACT

1.) Test and calibration of fiber optic test equipment.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

None.

## PARAMETER: OPTICAL FIBER LOCAL AREA NETWORK

REQUIREMENTS

1.) Standards for optical fiber local area networks (whatever the standards might be).

STATUS at NIST

1.) NIST has initiated some work in this area.

INDUSTRIES AFFECTED

1.) Aerospace Industry.
2.) Department of Defense.
3.) Telecommunications Industry.

APPLICATION and IMPACT

1.) New standards and measurement techniques will most likely be needed for the test, evaluation, and maintenance of optical fiber local area networks.

NEW REQUIREMENTS

None.

SPECIAL COMMENTS

1.) In short-haul (LAN) applications, the increase in component count (connectors, couplers, etc.) make the performance characteristics of these components and their interactions more critical than the fiber's.

PARAMETER: BACK REFLECTION MEASUREMENT OF FIBER OPTIC COMPONENTS

UNITS: dB

REQUIREMENTS

1.) No Old Requirements.

INDUSTRIES AFFECTED

1.) Telecommunications.

APPLICATION and IMPACT

1.) Test and calibration of fiber optic test equipment.

NEW REQUIREMENTS

1.) Back Reflection Measurement of fiber optic attenuators.
2.) Back Reflection Measurement of fiber optic power sensors.

SPECIAL COMMENTS

1.) As bit rates continue to increase the need to measure Back Reflections more accurately also increases.

## SUBCOMMITTEE IV: TEMPERATURE - PRESSURE

### CATEGORIES

| | |
|---|---|
| Electrolytic Conductivity | Pressure |
| Temperature | Heat Flux |
| Vacuum | Thermal |
| Gas Leak Rate | Conductivity |

### INTRODUCTION

The temperature pressure subcommittee has been restructured to remove the parameters associated with flow measurement. The remaining parameters, pressure, vacuum, leak, temperature, etc., relate to each other by their association within NIST with common management. NIST "Consultants" provided valuable information concerning needs expressed by their customers for calibration services and cooperated with this NMRC subcommittee in the presentation of a workshop at the 1988 NCSL Conference in Washington DC concerning pressure calibration as it related to NIST capability.

It is gratifying to report that several of the discrepancies reported in both the 1982 and the 1986 NMRC report have been satisfied either by additional services or by the issuance of SRMs. There are still gaps in the services that require solutions; however, the diminishing quantity of new deficiencies in the pressure/vacuum disciplines demonstrates that NIST efforts to fulfill industries needs are effective. The change in the temperature scale, ITS-90, due to be implemented in early 1990 will impact the temperature calibration parameters by eliminating some problem areas and creating new ones. Many of the deficiencies identified for temperature calibration have been corrected by NIST; however, the advent of the new scale will impose requirements that will require attention. Until the scale is completely defined the new requirements are not well known; however, since a major portion of the scale will depend upon the availability of a high temperature Platinum Resistance Thermometer, the availability of such an instrument becomes of prime importance. Also, the addition of many fixed points to the scale implies that NIST should provide calibration services for the cells required for these fixed points, assuming that they will be available in the commercial marketplace.

PRIORITIES

The implementation of ITS-90 will involve the NIST in the near future and must have the highest priority; however, within the Temperature and Pressure Division, the pressure calibration activity should place emphasis upon the development of "Improved Atmospheric Range Pressure Standards". This range commonly identified with manometry is assumed to lie between 2 psia and 500 psi. This activity is considered require emphasis because of the potential application that will benefit a wide range of users. One group of users, from the pharmaceutical industry, relies upon pressure measurements for process controls , e.g. Freeze Drying, which relate to the quality of the product and in part relate to the yields thereto; hence, profitability and loss. The accuracies available from the NIST are degraded by the progression of calibration from the NIST level to the production instrumentation. The resulting accuracies then require that greater allowances be made in the allowable ranges of pressure for control of processes. The process limits are accordingly broader loosening control. In the aircraft/air transportation industry, pressure measurements of aircraft engine performance factors relate to efficiency of the engines. Both civilian and military aircraft, using modern bypass turbines measure internal pressures to control clearances within the engine and pressure ratios to control power . All of these factors relate to fuel consumption which relates to in flight fuel efficiency; hence, fuel cost. Requests for on-board accuracies of 0.01% (100 ppm) have been made; however, this is the best accuracy available from the NIST for pressure calibration in this range at this time. Some customers have requested 5-10 ppm calibration accuracies. It is difficult to quantify the benefits due to the intangible nature of data available; but, savings to both the airline, military and many industrial activities would result from improved pressure calibration capability in the atmospheric pressure range .

## COMMITTEE MEMBERS

| CHAIRMAN | PARAMETER |
|---|---|
| Laurie H. Baker<br>Rockwell International<br>AMSD Metrology<br>Mail Stop HC02<br>3370 Miraloma Avenue<br>Anaheim, CA 92803<br>Tel: (714) 762-7864 | Pressure<br>Leak<br>Temperature<br>Thermal<br>Conductivity<br>Gas Leak Rate |

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|---|---|
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PARAMETER: ELECTROLYTIC CONDUCTIVITY

UNITS: Siemens/cm (mho, 1./ohm)

REQUIREMENTS

1.) Documentation/programs to assure commonality in measurement technology.

STATUS at NIST

1.) Documentation and SRMs are now available.

INDUSTRIES AFFECTED

1.) Electronic.
2.) Medical.
3.) Pharmaceutical.
4.) Power.

APPLICATION and IMPACT

1.) Pharmaceutical: Purity of fluids based upon water is critical.
2.) Electronic: Cleaning and processing at all levels of manufacturing requires pure, low conductivity water.
3.) Environmental issues, oceanography, health related issues, etc., depend upon the quality of fluids used for standards.

NEW REQUIREMENTS

A.) None.

SPECIAL COMMENTS

A.) None.

PARAMETER: PRESSURE

UNITS: kilopascals/$m^2$ (psi)

REQUIREMENTS

1.) Calibration of gas piston gages for P > 600 psi.
2.) Calibration of gas piston gages for P < 600 psi.
3.) Calibration of oil piston gages for 4000 to 40,000 psi.
4.) Pressure calibration above 40,000 psi up to and above 200,000 psi.
5.) Dynamic pressure measurement to the region of 1000 Hz. Pressure levels can be > 200,000 psi.
6.) Pressure measurements to support calibration of the atmospheric pressure range ( ~2 psia to 500 psi) with precision of 5-10 ppm.

STATUS at NIST

1,2.) Improvements are being studied for the gas piston measurement system to improve the present 50 ppm limits.
3.) Service is available to +/- 75 ppm accuracy to 15000 psi.
4.) Unknown.
5.) Unknown
6.) Some studies are under way to consider improvements.
A.) NIST and NMRC have conducted workshops to determine the needs.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Chemical.
3.) Medical.
4.) Petroleum.
5.) Pharmaceutical.
6.) Power, etc.

APPLICATION and IMPACT

1.) Pressure measurements are an integral part of the controls of many processes wherein the precision directly affects the quality and quantity of the product.



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PARAMETER: PRESSURE (CONTINUED)

NEW REQUIREMENTS

A.) Documentation to clearly define usage, calibration, and operation of piston gages.

SPECIAL COMMENTS

A.) None.

PARAMETER: TEMPERATURE

UNITS: Kelvin (K), Centigrade (°C), Fahrenheit (°F)

REQUIREMENTS

1.) Strip Lamp calibration and the availability of SRMs for high temperature, Radiation, thermometry become critical with the onset of ITS-90.
2.) Calibration or test services for fixed point temperature reference cells that will be required for ITS-90

STATUS at NIST

1.) Unknown.
2.) During the past few years, the services have gradually expanded and are expected to continue to be developed as the NIST prepares for ITS-90.
A.) The advent of ITS-90 will require the provision of calibration services for SPRT's to include the new range of temperatures.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Chemical.
3.) Medical.
4.) Petroleum.
5.) Pharmaceutical.
6.) Power.
7.) Steel, etc.

APPLICATION and IMPACT

1.) ITS-90 emphasizes the use of radiation thermometry for temperatures above the silver point.
2.) ITS-90 has include many new fixed points for the definition of the scale between 13.8 K and 962 °C.

NEW REQUIREMENTS

A.) Calibration services for SPRT's need to be extended to include the range specified by ITS-90.

SPECIAL COMMENTS

A.) None.

PARAMETER: VACUUM

UNITS: pascal (torr, mm-Hg, $N/m^2$, in-Hg, millibar)

REQUIREMENTS

1.) Extend the calibration range of SRG's to below $10^{-6}$ torr.
2.) Calibration to 10**-8 Torr for ionization type gages.
3.) Mass Spectrometer Calibration: 1-100 emu, sensitivity for partial pressure to 10**-10 Torr.

STATUS at NIST

1.) Some studies are under way
2.) Depending upon the leak program, some standards in pressure below 10**-6 Torr may be available in the near future.
3.) Unknown
A.) Studies are being planned for the transition pressure range.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Chemical.
3.) Home Appliance.
4.) Petroleum.
5.) Pharmaceutical.
6.) Power.

APPLICATION and IMPACT

1.) Pressure measurements in the medium to high vacuum areas affects many industries in that process yields depend upon reproducible conditions to be consistent.

NEW REQUIREMENTS

A.) Calibration in the transition range of pressures above $10^{-3}$ Torr.

SPECIAL COMMENTS

A.) None.

PARAMETER: VACUUM - LEAK RATE

UNITS: moles/sec (std-cc/sec, oz/yr, micron-$ft^3$/hr, etc.)

REQUIREMENTS

1.) Extend the range of helium leak rate standards calibration above the present limits to $10^{-10}$ std-cc/sec with an uncertainty of +/- 5.%.

STATUS at NIST

1.) A continuous program is under way to develop and extend the calibration range for gas leaks.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Electronic.
3.) Home Appliance.
4.) Medical.
5.) Pharmaceutical.
6.) Power.

APPLICATION and IMPACT

1.) For all industries, the leakage of encapsulated or sealed items affects the usable life cycle.

NEW REQUIREMENTS

A.) None.

SPECIAL COMMENTS

A.) None.

## SUBCOMMITTEE V: PHYSICAL/DIMENSIONAL/ACCELERATION/FORCE METROLOGY

### CATEGORIES

| | | |
|---|---|---|
| Dimensional | Hardness | Force |
| Gage Block | Surface Roughness | Mass |
| CMM | API Thread Gages | Acceleration |
| Laser System | Regular Thread Gages | Shock |
| Diameters/Cylinders | Angle | |

### INTRODUCTION

This report follows up on information compiled in the 1986 NCSL-NMRC report on physical and dimensional parameters. All of the information was gathered by the members of this committee as there were no (zero) inputs from industry from which to extract new measurement requirements. Much of this information was gleaned from a questionnaire/survey directed at the NIST consultants which was designed to find out about the problems industry has with NIST service and/or capability.

The mechanical/dimensional parameters listed in this report have been compiled in order of relative importance. Relative importance was based on several factors: number of users affected, financial impact, affects on accuracy and/or stability, and personal knowledge of the parameter.

Among the parameters listed two stand out as being somewhat more critical. These are listed below with a brief description of the problem.

1.) Coordinate Measuring Machines - General

There is a general need in industry for improved accuracy in CMMs. NIST could lend some of its expertise with the development of a MAP program(s), methods for material compensation of parts measured at other than STP, and the development of standard algorithms or equivalent types of control over algorithms used in direct computer control type machines.

INTRODUCTION (CONTINUED)

2.) Laser Measurement Systems - General

There is also a general need for NIST calibration or MAP service for laser measurement systems. The official NIST policy on the calibration of lasers is for service to proceed from the user to the vendor and from the vendor to NIST. The increasing popularity of lasers in dimensional measurement has lead to an increased number of vendors and an increased variety of laser types. These lasers are usually calibrated by comparing the wavelength of light of the standard to the unit under test. This method does not test the laser at its measurement interface.

## COMMITTEE MEMBERS

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|---|---|
| Robert J. Tobias<br>TRW<br>One Space Park S/2470<br>Redondo Beach, Ca. 90278<br>(213) 812-4673 | API Thread & Rings<br>Gage Blocks<br>Cylindrical Standards<br>Coordinate Meas. Mach.<br>Laser Standards<br>Angle<br>Shock/Vibration<br>Acoustics<br>Mass<br>Surface Roughness |
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| Theodore D. Doiron<br>National Institute<br>of Standards and Technology<br>Gaithersburg, MD 20899 | Gage Blocks<br>Line Standards<br>Sieves |
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| Richard Davis<br>National Institute<br>of Standards and Technology<br>Gaithersburg, MD 20899 | Force<br>Mass |

PARAMETER: Length - Coordinate Measuring Machine

UNITS: Inch/Meter

REQUIREMENTS

1.) Higher accuracy standard/methods for calibration of CMM's.
2.) MAP program for length measurements on large CMM's.
3.) MAP program for calibration of laser systems used in CMM calibration.

CURRENT STATUS AT NIST

1.) NIST currently lacks the capability for the measurement of ball and hole plate standards to the degree of accuracy needed by its customers. The higher capability needed should be ready sometime in 1989 with the purchase of a new precision CMM.
2.) No MAP program available for CMM length calibration is currently available through NIST.
3.) No Map program for calibration of laser systems used on CMM measurements is available through NIST.
A.) NIST is in the midst of an international round robin using three different ball plates each of different materials. This study would help a participating lab know the effect temperature has on materials being measured.
B.) The measurement of photomasks to an accuracy of 0.3 micrometers is beyond the current capability of NIST.
C.) Some testing is currently being done as described by the recent GIDEP alert #X1-A-88-01 (and #X1-A-88-01A).

INDUSTRIES AFFECTED

1.) Automotive.
2.) Aerospace.
3.) Microcircuit.
4.) Manufacturing.
5.) Department of Defense.

PARAMETER: Length - Coordinate Measuring Machine (CONTINUED)

APPLICATION AND IMPACT

Coordinate measuring machines are becoming the industry standard for high accuracy and precision measurements in quality control and inspection. They are used for a wide variety of measurements from mechanical parts and antenna inspection, to microcircuit measurements, to automated scanning devices. Some take essentially static measurements, while others take measurements 'on the fly'. Since the calibration and maintenance of CMM's to a high degree of accuracy is very time consuming, better methods and standards need to be researched so that the highest accuracies using the least amount of time can be achieved. The financial impact of the problems described is extremely difficult to calculate, but could have substantial affect on the quality end of many products checked with the new generation CMM's.

NEW REQUIREMENTS

A.) Methods for determining the material temperature compensation for items being tested on a particular CMM at temperatures other than 20 degrees Celsius.
B.) Measurement of Photomasks to an accuracy of 0.3 micrometers.
C.) Methods for determining the validity of manufacturers software algorithms for CMM's (or approved algorithm standards).

SPECIAL COMMENTS

The ANSI B89.1.12 specification for the performance evaluation of CMMs is generally very good though extensive. In addition, NIST/ANSI/ASME needs to address methods of identifying axial squareness errors as some manufacturers include this in their specifications.

PARAMETER: Length - Laser Measurement Systems

UNITS: Inch/Meter

REQUIREMENTS

1.) No old requirements.

CURRENT STATUS AT NIST

A.) NIST has no current service for calibration of laser systems. They believe that traceability should proceed from the user to the manufacturer to NIST.
B.) Unknown.

INDUSTRIES AFFECTED

1.) Manufacturing.
2.) Aerospace.
3.) Automotive.

APPLICATION AND IMPACT

The use of lasers for length measurement is commonplace today. Newly designed tools and machines now use laser setups instead of various types of scales and old tools are being retrofitted with lasers to take advantage of the high accuracy, precision and resolution that may be attained by their use. The future of the laser in measurement will be substantial in industry.

NEW REQUIREMENTS

A.) NIST calibration service for Environmentally Compensated Laser Interferometer systems whose accuracies are specified in the range of millionths of an inch.
B.) NIST needs to design a standard method for laser system calibration.

SPECIAL COMMENTS

Each manufacturer has a varying method for calibration of lasers. Some do a system comparison to a standard known length, while others compare the wavelength of light from the laser head and make adjustments to other equipment in the system. Standard methods need to be determined to give industrial users confidence in their "absolute" laser measurements. More information on NIST laser calibration policy may be found in NIST Technical note 1248.

PARAMETER: Length - Thread Plug and Thread Ring Gages

UNITS: Inches

REQUIREMENTS

1.) No old requirements.

CURRENT STATUS AT NIST

A.) NIST calibrates thread wires for use in the calibration of thread plugs.
B.) No MAP service is available.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Automotive.
3.) Manufacturing.

APPLICATION AND IMPACT

Thread plugs and rings are used to verify internal and external threads on mechanical parts and nuts/bolts. Better methods for thread ring gage calibration will allow for higher thread accuracies and a more comprehensive out-of-tolerance evaluation. This may also provide a basis for the extension of calibration intervals in some cases.

NEW REQUIREMENTS

A.) Software containing calibration tables, etc. of Federal Standard H28 for screw threads.
B.) Need more refined methods for calibration of thread ring gages. The industry standard method of verifying thread ring gages "by feel" as compared to a thread master gage gives a qualitative rather than quantitative measure. Out of tolerance reporting as required in Mil-Std 45662 is extremely difficult given these conditions.
C.) Measurement Assurance program for Thread plug gages.

SPECIAL COMMENTS

A.) None.

PARAMETER: Length - Surface Roughness

UNITS: Microinches/Micrometers ($R_a$)

REQUIREMENTS

1.) Need to verify linearity of multi-range analog and digital profilometers from 10 uin (0.25 um) to 2 000 uin (50 um).
2.) Need to verify surface roughness over the same range as 1.
3.) Need standard reference materials in the Angstrom range. These would be applicable to "non-contact" surface measurements in the following ranges:

| | | |
|---|---|---|
| 100 | - | 500 Angstrom |
| 500 | - | 1 000 Angstrom |
| 1 000 | - | 10 000 Angstrom |

CURRENT STATUS AT NIST

1.) NIST can certify standard step height specimens to ± 1%.
2.) NIST has SRMs available of 120 ± 3.2 uin (3 ± 0.8 um).

INDUSTRIES AFFECTED

1.) Semiconductors.
2.) Ball Bearings.
3.) Aerospace.
4.) Manufacturing.

APPLICATION AND IMPACT

Profilometers and surface roughness systems are used for making accurate surface finish measurements on critical surfaces. The absence of a series of SRMs over a range of roughness greatly inhibits the use and increases the uncertainty of most of these systems.

NEW REQUIREMENTS

A.) None.

SPECIAL COMMENTS

SRM step wafers are being provided primarily to meet the needs of the semiconductor industry and are unsuitable as stylus type roughness standards.

PARAMETER: Length - Gage blocks

UNITS: Inch/Meter

REQUIREMENTS

1.) Need higher accuracies ( ± 10 microinches for 20 inch block) for long gage blocks (5 - 20 inches).
2.) MAP program for long gage blocks.

CURRENT STATUS AT NIST

1.) Current accuracy is stated as ± 20 microinches for the 20 inch block.
2.) No MAP service available for long gage blocks.
A.) Higher accuracies using laser interferometry are only used for audit packages of approximately 8 blocks.
B.) NIST does not offer a lab certification service.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Automotive.
3.) Manufacturing.
4.) Calibration & Inspection.
5.) Department of Defense.

APPLICATION AND IMPACT

Gage blocks are used as primary standards for length in various manufacturing and quality control environments.

NEW REQUIREMENTS

A.) Higher accuracies for standard gage blocks using laser interferometry.
B.) Lab certification program by or in conjunction with NIST to eliminate burden of individual company surveys.

SPECIAL COMMENTS

Typically, 'master' sets of gage blocks are calibrated by NIST and the calibration lab will compare their 'transfer' standard sets back to the 'master'. By the time the shop floor gets a working set of gage blocks there are at least two (and probably more) transfers. With every transfer there should be some degradation in uncertainty or accuracy, yet typically 1:1 or 2:1 tolerance to NIST uncertainty ratios are still used. The NIST uncertainties should be lowered in order to give labs more confidence in their comparison measurements for length.

PARAMETER: Length - Cylindrical Standards (Includes Pins, Plugs, Pistons, Wires, Rolls, Cylinders.)

UNITS: Inch/Meter

REQUIREMENTS

1.) No old requirements.

CURRENT STATUS AT NIST

A.) NIST has the capability to measure cylinders between 0 and 1 inch to and accuracy of about ± 5 microinches.

INDUSTRIES AFFECTED

1.) Manufacturing.
2.) Aerospace.
3.) Pressure Gage Mfrs. & Users
4.) Thermodynamics

APPLICATION AND IMPACT

Many users are not affected by the relatively high uncertainties for cylinders at NIST. An example of an industry that is impacted are users of pressure gages. The accuracies of piston gages used in the measurement of pressure are limited by the ability to measure area, and therefore cylinder diameter. An increased capability to measure cylinder diameter would directly benefit pressure gage users. The immediate financial impact is minor and unknown.

NEW REQUIREMENTS

A.) Need uncertainties of ± 1 microinch in the range of 0 to 1 inch.

SPECIAL COMMENTS

A.) None.

PARAMETER: Angle - Angle (Includes Angle Gage Blocks, Autocollimators, Rotary Tables, Angular Encoders, Polygons)

UNITS: Arcseconds/Radians

REQUIREMENTS

1.) No old requirements.

CURRENT STATUS AT NIST

A.) NIST has the capability for measuring angle gage blocks, rotary tables, indexing tables, polygon mirrors and angular transducers to an uncertainty of approximately ± 0.2 arcseconds.

INDUSTRIES AFFECTED

1.) Aerospace.

APPLICATION AND IMPACT

Improvement in the basic accuracy of angle measurements is required in the event that many of the proposed SDI defensive systems are to realize their design performance goals. In the event that these SDI systems are completed, the effect of the measurement error would result in substantially increased cost in system operations. Standard manufacturing processes would not necessarily need the higher accuracies for form and fit design goals.

NEW REQUIREMENTS

A.) Calibration of very high resolution angular transducers to accuracies of around ± 0.02 to 0.04 arcseconds.

SPECIAL COMMENTS

The basic techniques for calibrating angle gage blocks, rotary tables, polygons, etc. have not changed for thirty years or more. NIST now believes that uncertainties up to 10 times higher can be achieved through control of environmental factors such as seismic disturbances, thermal effects, and refraction along with the addition of an automated system which utilizes the latest in laser technology.

**PARAMETER: Mass**

**UNITS: Pound (lb)/Kilogram (kg)**

REQUIREMENTS

1.) Faster turn around time for all mass calibrations.
2.) Mass calibrations in the range less than 1 milligram.

CURRENT STATUS AT NIST

1.) Slow Turn around times are still being suffered with.
2.) NIST has no capability in the range below 1 milligram.
A.) The NIST capabilities between 2 and 10 kg that needed improvement were:

| Nominal Value | Uncertainty |
|---|---|
| 10 kg | 15.5 milligrams |
| 5 '' | 10.0 '' |
| 3 '' | 7.8 '' |
| 2 '' | 6.6 '' |

B.) Current turn around time is unknown.

INDUSTRIES AFFECTED

1.) Pressure Metrology.
2.) Aerospace.
3.) Automotive.
4.) Nuclear.
5.) Microelectronics.

APPLICATION AND IMPACT

The weights in the 2 to 10 kg range are used as measurement standards in the application of weighing loads, etc. The financial impact of keeping standards with the uncertainties mentioned are unknown.

NEW REQUIREMENTS

A.) There have been a few requests (by the State Office of Weights and Measures, for example) for greater accuracy in the range between 2 and 10 kilograms.
B.) Faster turn around time for all mass calibrations.

PARAMETER: Mass (CONTINUED)

SPECIAL COMMENTS

1.) An uncertainty needs to be assigned to the 1 kg working standards used by NIST. (NCSL ad hoc committee 91.5 is currently addressing this problem.)
2.) The acquisition of better equipment could better the uncertainties in the 2-10 kg range.
3.) There is some indication at NIST that fractional weights between 1 and 500 mg are at times unstable at levels of about 1 microgram. This is significant since many users in industry have scales that can resolve to 0.2 micrograms.

PARAMETER: Length - API Thread and Ring gages

UNITS: Inch/Meter

REQUIREMENTS

1.) No old requirements.

CURRENT STATUS AT NIST

A.) NIST has established an uncertainty of ± 0.000 1'' for the standards used in the measurement of larger sized regional master gages. The Tolerance to uncertainty ratio is approximately 2:1 which is barely acceptable and needs improvement.

B.) No MAP service for screw threads is currently available from NIST.

INDUSTRIES AFFECTED

1.) Automotive.
2.) Aerospace.
3.) Manufacturing.

APPLICATION AND IMPACT

Thread Plug and Ring gages are used in a variety of manufactured goods. The integrity of correctly sized threads results directly in better fit and form of the final product, creating a higher quality and safer product.

NEW REQUIREMENTS

A.) NIST needs to develop a lower uncertainty for the measurement of pitch diameter for the larger sizes of regional master gages. Tolerances for these gages is ± 0.000 2''.

B.) MAP service for the measurement of screw threads.

SPECIAL COMMENTS

There is an existing problem of pitch diameter measurements in U.S. industry today. Few laboratories are able to routinely measure pitch diameter with enough confidence to state an uncertainty equal to one-tenth the tolerance. A round robin of screw thread gages could bring this problem more clearly to light.

PARAMETER: Hardness

UNITS: Rockwell/Vickers/Brinell scales

REQUIREMENTS

1.) Need SRMs for items not tested by microhardness.

CURRENT STATUS AT NIST

1.) NIST has not seen a need to develop and maintain standards for Rockwell hardness as they believe that the current standards used by the manufacturers of hardness testing equipment is adequate. It is also their belief that with the present state of technology, control of the individual parameters of force, depth of penetration, and rate of load is such that there is no need for direct traceability via SRM standards.

INDUSTRIES AFFECTED

1.) Aerospace.

2.) Automotive.

APPLICATION AND IMPACT

The Rockwell regular hardness testers are used on raw stock and some finished parts to determine the relative hardness of the material in question. There will be no financial impact whether or not there are hardness SRM standards available.

NEW REQUIREMENTS

A.) There are no new requirements.

SPECIAL COMMENTS

NIST has recently introduced microhardness SRM standards. These were a necessity due to the nature of the microhardness measurement. The development of a set of regular Rockwell hardness standard SRMs would be a convenience for direct traceability, and possibly increase the accuracy of our hardness standards.

**PARAMETER: Haze**

**UNITS: Percent transmission**

REQUIREMENTS

1.) Haze sample SRMs for verification of haze meters over a range of 0-100% transmission with accuracies to ± 0.1%.

CURRENT STATUS AT NIST

1.) No calibration or SRM service is currently available at NIST.

INDUSTRIES AFFECTED

1.) Aerospace.

APPLICATION AND IMPACT

Haze meters over a range of 0-100% transmission. Traceability to NIST is required for quantitative evaluation of haze in and around the cockpit of various aircraft. This would have little financial impact.

NEW REQUIREMENTS

A.) No new requirements.

SPECIAL COMMENTS

The problem of traceability seems to be a unique problem for the aircraft industry. More investigation/inquiry should be made to address applicability.

PARAMETER: Gloss

UNITS: Percent transmission

REQUIREMENTS

1.) Gloss sample SRMs for verification of gloss meters over a range of 0-100% transmission with accuracies to ± 0.1%.

CURRENT STATUS AT NIST

1.) No calibration or SRM service is currently available at NIST.

INDUSTRIES AFFECTED

1.) Aerospace.

APPLICATION AND IMPACT

The calibration of meters which detect surface glossiness via percent transmission. This would have impact on aerodynamic considerations in design of aircraft. This would have little financial impact.

NEW REQUIREMENTS

A.) None.

SPECIAL COMMENTS

Gloss standards are available from at least one source (Garner/Hunt laboratories) who show traceability to an ASTM method of calibration. Gloss is measured as a function of transmission with respect to angle.

## SUBCOMMITTEE VI: FLOW

### CATEGORIES

Flow (Gas)
Flow (Liquid)
Fluid Density
Hygrometry
Particle Standards
Viscosity

### INTRODUCTION

This subcommittee was newly organized in the beginning of 1988 and suffered the loss of the original chairman late in 1988 due to his reassignment. Because the replacement chairman began his tasks late in the year and because a staff to support the original chairman had not yet been assembled, the review of NIST capabilities for all of the categories was not possible this year. Work to recruit subcommittee members is under way at this time and it is expected that full coverage will be available for subsequent efforts.

Nevertheless, studies have been made regarding the major category for this subcommittee, Flow Calibration. The results of this study, with the assistance of the NIST consultant, Dr. George Mattingly, have enabled the presentation of the following:

1.) Gas Flow -( Natural Gas Orifice Metering) Errors in natural gas orifice metering can have a significant impact on the profitability of buying and selling natural gas. GRI is currently developing a flow measurement capability to support orifice flowmeters in the range of 200 to 600,000 CFM with an absolute accuracy of .25%. Traceability to NIST will be maintained via fundamental units of mass, length, etc. Traceability via flow is not possible above 3000 SCFM nor recommended. However, continued research into improving the accuracy of orifice metering "through optimum redesign of pressure tap placement, the development of new orifice equations, the development of a method for averaging pressure fluctuations, etc." should continue. A major participant in this effort should be NIST.

INTRODUCTION (CONTINUED)

2.) Liquid Flow - Jet Aircraft Fuel Flow Measurement
Aircraft manufacturers are requesting increased accuracy in fuel flow measurements from jet engine manufacturers. Specifically, a .25% indicated reading measurement uncertainty in the range of 40 to 250 GPM. General Electric is currently developing a positive displacement standard with .05% measurement uncertainty over the required range to calibrate the jet engine fuel flowmeters. G.E. plans to provide measurement traceability to NIST via fundamental units of measurement (i.e. mass, length etc.) since NIST flow measurement uncertainty for this range is only .13% indicated reading.

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PARAMETER: LIQUID and GAS FLOW

UNITS: (volume or mass/time)

REQUIREMENTS

1.) Measurement Assurance Program (MAP).
2.) Documentation - Gas flow calibration.
3.) Liquid flow calibration to 250 GPM.
4.) Steam flow calibration.

STATUS at NIST

1.) Laboratory intercomparisons in the form of MAP's and/or Round Robins are essential to reducing uncertainties associated with flow measurements using different measurement techniques and at different laboratories. Round robins in liquid flow have been initiated by NIST with results indicating many laboratories differing by more than .1% indicated reading which is significant.

2.) Documentation is available for data essential to orifice flowmetering; additional information specifically in the area of improving orifice equations is required. Recent publications are:
a.) "Fluid Metering Research at NBS", C.I. 84-R767
b.) "Workshop on Fundamental Research-Issues in Orifice Metering", GRI-84/0190

3.) Present liquid flow accuracy is +/-0.13% indicated reading. Efforts are underway to upgrade this capability to support new fuel flow measurement requirements instigated by the aircraft industry.

4.) High pressure, high flow rate steam measurements are required by the oil industry for forced extrusion of oil. However, no capability at NIST exists for this type of flow measurement.

INDUSTRIES EFFECTED

1.) Aerospace.
2.) Chemical.
3.) Medical.
4.) Petroleum.
5.) Pharmaceutical.
6.) Power.
7.) Defense.

PARAMETER: LIQUID and GAS FLOW (CONTINUED)

APPLICATION AND IMPACT

1.) Fluid and gas flow measurements are fundamental to the control of processes in many industries. Their quality (i.e. accuracy) has a direct affect upon the costs associated with product sales and can offset the performance of products. This is especially evident in the natural gas industry where small errors in gas flow measurement can result in millions of dollars lost to that industry or to the consumer.

NEW REQUIREMENTS

A.) Multi-phase flow.
B.) Cryogenic flow.

SPECIAL COMMENTS

1.) Solid-liquid flow (multi-phase) calibration facilities are currently being developed at NIST. Services to be offered will be unique in the U.S..

PARAMETER: HYGROMETRY

UNITS: % relative humidity (R.H.)

REQUIREMENTS

1.) No old requirements.

STATUS at NIST

A.) Unknown.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Computer.

APPLICATION and IMPACT

1.) Environmental monitoring.

NEW REQUIREMENTS

A.) Seminar and literature on techniques, etc.

SPECIAL COMMENTS

A.) None.

PARAMETER: PARTICLE STANDARDS

UNITS: micrometers or microinches in diameter

REQUIREMENTS

1.) Spherical Particle SRMs from 0.5 to 1.0 um diameters with accuracies of +/- 5.%.

STATUS at NIST

1.) Have 0.3 and 0.9 um SRMs made out of polystyrene available with stated uncertainty of 1.%. Glass spherical particle SRMs are now available for 10. um and are expected to be available for 0.1, 3., and 30. um within one year.

INDUSTRIES AFFECTED

1.) Aerospace.
2.) Medical.
3.) Micro-Electronics.

APPLICATION and IMPACT

1.) Determination of state of clean and semi-clean rooms.
2.) Light and electrical zone flow through counters.

NEW REQUIREMENTS

A.) None.

SPECIAL COMMENTS

1.) Glass spheres are available for sizes 34-1900 um diameter. These are intended for use in the calibration of test sieves. An adequate range of particle spheres for the calibration linearity check is 0.1 to 30. um.

FINAL COMMENTS

The data presented in this report by the six subcommittees was gathered during 1988. Care was taken in checking with personnel from the NIST (as listed by each subcommittee) in order to minimize erroneous statements. The information provided by each subcommittee is presented in the form in which it was provided with only minor editorial changes to fit thegeneral format for this report.

Membership within the various subcommittees is very fluid and those readers interested in this type of work and who are able to spare some free time are strongly encouraged to join and help this survey endeavor. It is important to realize, however, that members have to travel once or twice a year (usually meetings are scheduled during conferences or seminars) and that many phone calls have to be made during the year; not to mention the writing of a summary report once every 12 or 24 months.

Since these committees are scheduled to be active for the foreseeable future, further input either in verbal or in written form should be forwarded to the respective chairperson. It is extremely important for all members of metrology to keep alert as to the present and future needs in standards availability and primary standards calibration support. Hence active participation by all members and non-members of NCSL is a must for a sound U.S. technology base.

Finally, the reader should be aware of some very serious shortcomings in metrology as identified in this report. Even though some of these needs are clearly identified with the NIST, there are also many that have been generated by various U.S. manufacturers or are being driven by government programs. By marketing or developing instruments that can not be supported via primary standards through the use of existing programs or short-term future hardware, entire projects can be put in jeopardy. Clearly, technology marches on but it would behoove all of us to thrive for the coordination of standards needs as identified by various factions.

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George Uriano, NBS Representative

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September 1984
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NISTIR 89-4057

# Emerging Technologies in Electronics ... and their measurement needs

Prepared by the Managers and Staff of the
Center for Electronics and Electrical Engineering

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(Formerly National Bureau of Standards)
National Engineering Laboratory
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Gaithersburg, MD 20899

March 1989

National Bureau of Standards became the National Institute of Standards and Technology on August 23, 1988, when the Omnibus Trade and Competitiveness Act was signed. NIST retains all NBS functions. Its new programs will encourage improved use of technology by U.S. industry.

**U.S. DEPARTMENT OF COMMERCE**
**Robert Mosbacher, Secretary**
**Ernest Ambler, Acting Under Secretary for Technology**

**NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY**
**Raymond G. Kammer, Acting Director**

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## Foreword

This NIST Internal Report has been prepared by the Center for Electronics and Electrical Engineering (CEEE) within NIST. The report identifies emerging technologies in electronics that CEEE believes will require increased measurement support from CEEE in coming years. The emerging technologies described here are new to the marketplace or are experiencing major technological advances.

This report is an internal planning document. The document is designed to stimulate feedback that CEEE needs to refine its plans for developing measurement capability to support emerging electronic technologies that are important to the national interest. Note that the plans that are associated with "future initiatives" in this document are clearly labeled. They are proposals developed by CEEE. They have not been officially approved by NIST Management or DOC Management. Rather, they represent the current best thinking of CEEE's Management and are subject to review, modification, or deletion by NIST and DOC Management.

The FY 1989 funding projections in this document are estimates, and all funding data are working figures used at the Center level, aggregated in amounts associated with Center analysis of technical work areas, which in most cases do not correspond to amounts in official NIST accounting records, where aggregations may be prepared differently for NIST purposes.

EMERGING TECHNOLOGIES IN ELECTRONICS

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## EMERGING TECHNOLOGIES IN ELECTRONICS
### Overview

The emerging technologies shown below are those that CEEE believes will require increased measurement support from CEEE in coming years. Also shown are the types of measurement support that CEEE: (1) is providing in its present FY 1989 program; (2) will provide if pending FY 1990 initiatives now before Congress are approved; or (3) will provide if future initiatives proposed by CEEE are ultimately approved. The "Key" at bottom defines the codes used.

| | Present FY 1989 Program | | | Pending FY 1990 Initiative | | | Future Initiative | | |
|---|---|---|---|---|---|---|---|---|---|
| **Semiconductors** | | | | | | | | | |
| Silicon Very Large Scale Integration | M | P | D | - | - | - | M | P | D |
| Silicon Ultra Large Scale Integration | - | - | - | - | - | - | M | P | D |
| Compound Semiconductor Integration | M | P | D | - | - | - | M | P | D |
| **Lightwaves** | | | | | | | | | |
| Optical Fiber Communications | - | - | D | - | - | D | M | - | D |
| Optical Fiber Sensors | - | - | D | - | - | - | - | - | - |
| Optical Information Storage | - | - | - | - | - | - | - | - | - |
| Optical Signal Processing & Computing | - | - | - | - | - | - | - | - | - |
| Lasers | - | - | D | - | - | - | - | - | - |
| **Microwaves** | | | | | | | | | |
| High Performance Components | - | - | D | - | - | - | M | - | D |
| Integrated Circuits | - | P | - | - | - | - | M | - | D |
| Integrated Antennas | - | - | - | - | - | - | M | - | D |
| **Superconductors** | | | | | | | | | |
| High Temperature Superconductors | M | P | D | M | P | D | M | P | D |
| Low Temperature Superconductors | M | P | D | - | - | - | - | - | - |
| **Magnetics** | | | | | | | | | |
| High Density Information Storage | M | - | - | - | - | - | M | - | D |
| High Performance Electronics | M | - | D | - | - | - | M | - | D |
| High Efficiency Motors, Generators, Transformers | M | - | - | - | - | - | M | P | D |
| Non-Destructive Evaluation | M | - | D | - | - | - | M | P | D |
| **Video Technology** | | | | | | | | | |
| High Resolution Displays | - | - | - | - | - | - | - | - | - |
| High Resolution Vision | - | - | - | - | - | - | - | - | - |
| High Definition Television | - | - | - | - | - | - | - | - | - |
| **Smart Systems** | - | - | D | - | - | - | - | - | - |
| **Bioelectronics** | - | - | - | - | - | - | - | - | - |

Key: M = Materials characterization measurements
P = Process control measurements
D = Device characterization measurements

EMERGING TECHNOLOGIES IN ELECTRONICS
Funding Levels

All funds shown below are directly appropriated funds; funds from other agencies are not shown. The first column shows the present FY 1989 levels of funding for related areas of programmatic activity. Those levels are assumed unchanged in future years. The second column shows additional funding for new work in pending FY 1990 initiatives now before Congress. The third column shows further funding in future initiatives proposed by CEEE but not yet approved. The "Key" at bottom defines the codes used.

| | Millions of Dollars | | |
|---|---|---|---|
| | Present FY 1989 Program | Pending FY 1990 Initiative | Future Initiative |
| Semiconductors | | | |
| Silicon Very Large Scale Integration<br>Silicon Ultra Large Scale Integration<br>Compound Semiconductor Integration | 4.2 | C | C |
| Lightwaves | | | |
| Optical Fiber Communications | 2.1 | 2.6 | B |
| Optical Fiber Sensors | 0 | 0 | - |
| Optical Information Storage | 0 | 0 | - |
| Optical Signal Processing & Computing | 0 | 0 | - |
| Lasers | 0.3 | 0 | - |
| Microwaves | | | |
| High Performance Components | 2.5 | | |
| Integrated Circuits | 0 | 0 | B |
| Integrated Antennas | 0 | | |
| Superconductors | | | |
| High Temperature Superconductors | 2.8 (N) | 0.7 (N) | A (N) |
| Low Temperature Superconductors | 0.5 | 0 | - |
| Magnetics | | | |
| High Density Information Storage<br>High Performance Electronics<br>High Efficiency Motors, Generators, Transformers<br>Non-Destructive Evaluation | 0.3 | 0 | A |
| Video Technology | | | |
| High Resolution Displays | 0 | 0 | - |
| High Resolution Vision | 0 | 0 | - |
| High Definition Television | 0 | 0 | - |
| Smart Systems | 0 | 0 | - |
| Bioelectronics | 0 | 0 | - |

Key: "A" means less than $5M per year
"B" means $5M to $10M per year
"C" means more than $10M per year
"(N)" means NIST-wide program
"-" means no initiative yet developed

EMERGING TECHNOLOGIES IN ELECTRONICS
Initiative History and Technological Trends

For selected elements from the first five categories of emerging technologies listed above, CEEE has developed initiatives to seek increased funding for expanded measurement support in upcoming years. Those initiatives are in various stages of development and processing. The status of each of these initiatives is described below. In addition, for all eight of the emerging technologies listed above, a brief summation is provided of the technological advances that are driving the need for increased measurement support.

Semiconductors

CEEE has developed an initiative entitled "Advanced Semiconductor Metrology" for an expanded NIST-wide program of measurement support. The initiative addresses materials measurements, process control measurements, and device measurements. The initiative was proposed but not adopted for the FY 1989 budget and the FY 1990 budget. Funding will be sought for this program again in a subsequent year. A description of this future initiative is attached.

Semiconductor integrated circuits are moving to reduced device size, increased integrated circuit density, and increased device speed. In addition, the special capabilities of both silicon and compound semiconductor technologies are being exploited. The measurement capability required to support these technological advances is addressed by the future initiative.

Other major technoiogical advances not addressed by the initiative are on the horizon. Specific examples include: (1) quantum confinement devices made from compound semiconductors that offer 100 times the device density and 1000 times the speed of current devices; (2) diamond semiconductors that can operate at very high temperatures for greater environmental tolerance and reduced cooling problems; (3) semiconductor micromachines; and (4) photocells of greatly improved efficiency.

Lightwaves

CEEE has developed an initiative entitled "Lightwave Measurement Technology" requiring $10M per year of funding. It focuses on device and materials measurements for optical fiber communications systems. Three pieces of this initiative have been approved by Congress in the budgets for FY 1987 ($0.95M per year), FY 1988 ($0.5M per year), and FY 1989 ($0.4M per year). A request for an additional $2.6M per year is included in the FY 1990 budget now before Congress. Funding for the balance of the initiative will be sought in a future year. A description of the work addressed by the several components of this initiative is attached.

Optical fiber communications systems are moving to (1) higher data rates of 20 gigabits per second at least; (2) improved or new components for local area networks to supplement long-distance lines already in place; and (3) improved components for undersea cables. Measurement support for each of these advances is provided by the proposed initiative.

There are several other emerging lightwave technologies that are beyond the scope of the initiative:

Fiber sensors are now emerging and are exhibiting extraordinary sensitivity, compact size, high environmental toughness, and broadening applicability for diverse measurements. Sensors that measure electrical parameters may become the controlling sources of information in the national power grid. Sensors that measure mechanical parameters, like strain, may lead to smart structures. Smart structures include composite fiber materials with built-in fiber sensors that report on material stresses, aging, or impending failure for applications in aircraft and building structures.

Optical information storage offers high information density, inexpensive removable media, and reduced probability of catastrophic failure.

Optical computing and optical signal processing offer dramatic increases in computing speeds, particularly when employing intrinsic parallel processing through imaging.

Laser technology is advancing rapidly and finding expanded application in industrial processing, medicine, and other fields, in addition to its traditional stronghold of scientific research and development.

Microwaves

CEEE has developed an initiative entitled "Microwave Measurement Technology". Funding for this initiative will be sought in a future year. This initiative focuses on device and materials measurements. It does not support process control measurements or measurements made inside individual devices to support design. Many of the key measurements made inside devices and some of the needed process control measurements will be addressed by the compound semiconductor component of the comprehensive "Advanced Semiconductor Metrology" initiative noted above. A description of the microwave initiative is attached.

Microwave systems are moving to higher performance levels, higher frequencies, and integrated-circuit form to realize diverse applications including: microwave electronics for high definition television (HDTV), for fiber optic communications, and for computer circuitry; vision systems for robots; on-board wind-shear detection systems for airplanes; collision-avoidance radar for automobiles; direct broadcast systems employing satellites; and local communications and radar systems for industrial and corporate applications. Ultimately, it will be possible to place an entire microwave system with transmission and reception electronics and phased array antenna on an individual wafer a few inches in diameter for robot vision or automobile collision radar.

Superconductors

Congress provided NIST with $2.8M per year of funding for high temperature superconductors beginning in FY 1988 prior to receipt of

NIST's first initiative request. The resulting NIST-wide program supports development of materials measurements, process control measurements, and device measurements; it also supports development of superconducting electronic devices with emphasis on measurement applications. For FY 1989 Congress required that NIST allocate an additional $2M of existing funding to high temperature superconductors for one year. The present program for FY 1989, which is operating at the $4.8M level for one year, is described in the attached "Superconductor Program Summary". The FY 1990 budget now before Congress requests an additional $0.7M per year. Those funds will enable NIST to increase its measurement support for the recently discovered second-generation high temperature superconductors whose more complex structures present especially difficult measurement problems. Additional funding will be sought in a future year, but formal plans have not yet been developed. For low temperature superconductors, CEEE presently has no plans to pursue additional funding.

High temperature superconductors promise products for electronics, electric power systems, medicine, transportation, and research. Electronic products include high speed computer chips and sensitive measurement devices for everything from electric current to signals from stars. Electric power products include motors and generators of great power but small size, current limiters, load-leveling equipment, energy storage equipment, and efficient transmission lines. Transportation products include propulsion systems for ships and for levitated trains with speeds over 300 mph (already demonstrated in Japan with the low temperature superconductors). Medical products include powerful magnets for medical diagnostic machines (already a $2 billion per year industry for the low temperature superconductors). Research products include new magnets for fusion research and high energy accelerators. Many other products are known to be possible; others are yet to be conceived. Low temperature superconductors support many of these applications already and will be employed in the new Superconducting Super Collider, a $4.4B project.

Magnetics

CEEE is presently developing an initiative entitled "Advanced Magnetics Metrology". Funding for this initiative will be sought in a future year. The initiative addresses materials measurements and device measurements for the magnetic recording and electronics industries. It also addresses materials measurements, process control measurements, and device measurements for high efficiency motors and generators and other large scale applications. A preliminary draft of this initiative, which will be expanded and refined later, is attached. Other Centers within NIST are developing complementary plans that will likely be integrated at a later date.

Advanced magnetic materials and technologies promise continuing improvements in the density of information storage in magnetic systems. They also promise higher efficiency for motors and generators and higher performance levels for electronic components that require magnetic elements, such as microwave phase shifters based on ferrites. New magnetic technology offers major advances in sensitivity and resolution

for electronic systems for non-destructive evaluation (NDE). NDE systems support materials processing and enable evaluation of the integrity of critical structures, such as reactor components, aircraft frames, and building supports, before they fail.

Video Technology

CEEE has many of the key skills required to provide measurement support for video technology and is now providing some support for selected device technologies for vision systems through its semiconductor program. Also, as part of its microwave initiative, CEEE has included funding for development of measurement support for microwave integrated circuits which will be needed for signal processing for HDTV, among other applications. CEEE has not developed plans to seek additional funding explicitly for video technology. The outcome of the decision by U.S. industry on whether to mount a major effort on high definition television will be a major factor in CEEE's own decision.

Advances in video technology will dramatically affect diverse applications including computer technology, "picture" phones, television, aerospace systems, and automobiles (unobstructed electronic rear view mirrors and electronic maps). Electronic systems capable of processing enormous bandwidths of information in real time will be required to support these displays. High resolution vision systems with broad bandwidth capability will be needed for robot vision, satellites, broadcasting, and many other applications. Flat screen displays will make large screen displays more practical, will widen potential applications, will provide improved display quality, and will ultimately reduce the cost of displays considerably.

Smart Systems

Smart systems include those employing artificial intelligence, expert systems, neural networks, adaptive electronics, self-calibrating electronics, and a variety of other capabilities. They promise a new generation of electronic instruments. They will be essential to the design, manufacturing, and maintenance of complex systems. CEEE is active in a very limited way in some of these areas but has not yet developed a plan for an expanded program. However, the importance of smart systems to electronics and electrical engineering is a certainty.

Bioelectronics

New bioelectronic systems offer potential (yet to be assessed) for key advantages relative to conventional electronics: (1) self-assembly - circuits that can be "grown"; (2) small size - 50 nanometer structures, possibly in three dimensions; (3) high computing speed - bioelectronic processes that handle so much information in a single step that even millisecond bioelectronic processes can beat nanosecond electronic processes; (4) high energy efficiency; (5) flexible biological interface - ability to interface directly with biological systems, including man; (6) new sensors - capable of recognizing complex materials or patterns; (7) high reliability; and (8) intelligence - imitation of neural and intelligence patterns of biological systems to perform very complex

functions. CEEE feels that it is too early to define an expanded program of measurement support for this emerging field of bioelectronics, but its prospects merit continued close monitoring.

Other Developments of Interest to CEEE

Two other major developments are not "emerging technologies" in the usual sense but are of great interest to CEEE. One is the trend toward basing procurement actions on certification of the quality of a manufacturing process rather than on certification of the quality of the final product made by the manufacturing process. This concept is particularly important for complex products whose quality cannot be readily tested. In the semiconductor industry, this trend is referred to as "qualifying processes" rather than "qualifying devices". Accommodating this trend has been an important part of the planning for the initiative on Advanced Semiconductor Metrology and will become increasingly important for other areas of electronic technology. A second trend is the development of universal computer-based descriptions for the design and manufacture of components and systems ranging from transistors to battleships. These universal descriptions lead to a software catalog of standard parts for multiple applications and reduce the cost of the design of new systems, the modification of those systems, and the maintenance of those systems.

ADVANCED SEMICONDUCTOR METROLOGY
Future Initiative
Project Plan

Introduction

The competitive problems faced by the U.S. semiconductor device and semiconductor manufacturing equipment industries are discussed in the press almost daily. These industries are vital to the U.S. economy, affecting not only the $223 billion electronics industry but the many other sectors of the economy that depend on electronics. Japan and the United States are fighting for the $24 billion worldwide semiconductor device market and the $7 billion semiconductor manufacturing equipment market. Japanese quality and low prices are legendary.

The U.S. still holds a slight technological edge in the areas of ion implantation, thin film epitaxy, and film deposition and etching, but the Japanese have funded strong programs in these areas. The U.S. has lost the lead in optical lithography and in preparation of high quality semiconductor materials and is losing the lead in processing equipment. The Japanese are leading in technologies and their supporting equipment that U.S. companies must possess if they are to compete successfully, and the Japanese are out spending the U.S. industry for capital improvements. These technologies include microwave plasma processing, radiation sources for lithography, electron and ion microbeams, laser-assisted processing, compound semiconductor processing, and three-dimensional device structures. Many significant studies, including the National Research Council's on "Advanced Processing of Electronic Materials in the United States and Japan" (1986), have emphasized the seriousness of the U.S. deficiency in semiconductor manufacturing technologies. This work plan directly responds to this issue by addressing the metrological infrastructure needed for such advanced processing technologies.

Impact

Semiconductor industry 1985: (millions) [Source: Dataquest]

| | Capital spending | Revenues | Spending/revenues (%) |
|---|---|---|---|
| U.S. merchant firms: | $2211 | $11272 | 20 |
| Japanese firms: | 3346 | 10185 | 33 |

Typical company R&D levels in both the U.S. and Japan are 10 percent of revenues, so each country's industry spends somewhat over $1 billion annually. The long term nature of Japanese research is illustrated by the current Japanese Government funding for microelectronics superlattice devices 1981-1990, $49M; three-dimensional IC's 1981-1990, $55M; and IC's for extreme conditions 1981-1985, $49M. [Source: MITI] Companies at least match this expenditure on these programs.

Microstructures at dimensions below one micrometer form the building blocks for the next generation of semiconductor electronic devices. This work plan is for research and development in microstructure science and technology leading to new measurement techniques and artifacts needed for materials, device, and equipment evaluation and process and quality control. It will enable NBS to develop and deliver essential measurement methods needed to support U.S. companies in their efforts to manufacture competitively

semiconductor devices for the 1990's. Key reference data, better models, and improved measurement methods for microelectronics will allow more accurate device design and improved process control by U.S. industry and improve its competitiveness. More reproducible materials processing and higher quality materials can significantly improve yields and lower costs. The transition by industry to submicrometer-scale devices will be aided by NBS contributions. Development of better measurement methods will provide the basis for industrial voluntary standards which assure product compatibility and which support efficient market transactions.

Summary of NIST Plan

The semiconductor initiative is a NIST-wide effort. The list that follows summarizes the key elements of the plan.

1. Metrology for Advanced Semiconductor Materials and Structures
1.1 characterization of layers
1.2 models for these processes
1.3 spatial variations in layer properties
1.4 properties of the interfaces between layers

2. Metrology for Critical Semiconductor Processes
2.1 patterns and defects in layers
2.2 diagnostics, data, and models for plasma processes
2.3 measurements of patterns in layers
2.4 fundamental information on plasma chemistry
2.5 contaminants in process gases
2.6 fundamental information on plasma physics

3. Metrology for Advanced Semiconductor Devices
3.1 device measurements by advanced beam methods
3.2 device package properties
3.3 models for advanced devices

4. Process Metrology for Advanced Semiconductor Manufacturing
4.1 assessing performance of manufacturing processes
4.2 improved statistical manufacturing process control
4.3 efficient testing of complex circuits

5. Surface structure effects in film growth and properties
5.1 structure at early stages of epitaxial film growth
5.2 physical structure and microcomposition of lithographic structures
5.3 segregation and diffusion at interfaces on an atomic scale
5.4 atomic structure at buried thin-film interfaces
5.5 chemical states at interfaces
5.6 theoretical support for 5

6. Mechanisms in surface processing
6.1 probes for surface-chemical processes
6.2 fundamental mechanisms in electron and photon beam lithography
6.3 structural and topographic surface changes after surface processing
6.4 theoretical support for 6

7. Standard reference data and materials
7.1 measure, compile, and evaluate critical data
7.2 new Standard Reference Materials
7.3 Electronic Materials Data Center

8. Advanced Analytical Techniques for Semiconductor Technology
8.1 high energy analytical techniques
8.2 ultratrace measurements for advanced semiconductors
8.3 microbeam analysis at the nanometer scale

Details of NIST Plan

The following text describes each element of the NIST-wide plan, using the same section numbers as in the summary above.

1. Metrology for Advanced Semiconductor Materials and Structures

1.1 GOALS: Development of electrical and optical techniques for characterizing epitaxial layers and heterostructures to obtain their dimensions, composition, and optical and electrical properties and to evaluate their suitability in high-speed electronic and optoelectronic applications. Fundamental studies of the physics of the initial stages of growth of epitaxial layers of compound semiconductors.

Develop the capability to prepare and characterize epitaxial layers and structures of the highest possible quality. Employ precise optical probes for determining sticking coefficients, adsorption energies, and other information needed for detailed understanding of heteroepitaxial growth. Use highly perfect, well-characterized epilayers to generate reference data for the composition dependence of physical and electronic properties such as bandgap, effective masses, spin-orbit splitting, mobility, impurity state binding energies, heterojunction band offsets, lattice constant, phonon energies, etc. As appropriate, use these specimens as a basis for standard reference materials for properties such as composition, band gap, or lattice constant and for the uniformity of these properties.

MILESTONES

Year 1: Design and construct apparatus for molecular beam epitaxy (MBE) with dual growth chambers suitable for the growth of large gap materials (GaAs/GaAlAs) for digital applications and small gap materials (InSb/HgCdTe) for optoelectronics.

Year 2: Assess the feasibility and relative merit of various optical and x-ray techniques for determining the composition and compositional uniformity of semiconductor alloy epilayers.

1.2 GOALS: Develop generic physical models for submicrometer structures. Complete understanding of the physics of devices and materials is essential for the development of good metrology. Models and computational techniques are important tools for developing that understanding. Develop accurate and computationally efficient methods for describing the effects of small dimensions, abrupt interfaces, and large composition or doping gradients on the electronic and vibrational states of semiconductors. Use these models in the interpretation of experimental data and the refinement of device models.

MILESTONES

Year 1: Determine effects of high doping gradients and bandgap discontinuities on the formation of band tails and impurity bands in moderately to heavily doped semiconductor alloys.

Year 2: Determine the effects of bandgap narrowing on the design and performance of heterojunction optoelectronic devices such as lasers and photodetectors.

1.3 GOALS: Develop methods of surface analysis for evaluating surface properties as a function of process variables and for determining lateral variation of electrical and optical properties of semiconductor surfaces. Provide facilities for in-situ characterization of surfaces during MBE growth. Study growth process and its influence on the optical and electrical properties of epilayers. Surface properties become increasingly dominant as the scale of device dimensions becomes less and less.

MILESTONES

Year 1: Design and construct surface characterization sub-system for MBE apparatus.

Year 2: Design and construct in-situ surface characterization and modification facilities for MBE system.

1.4 GOALS: Develop techniques to characterize the interfaces present in the active regions of devices. These include metal-semiconductor contacts (both ohmic and Schottky), heterojunctions, and other interfaces. Develop sensitive methods based on x-ray absorption and diffraction, electron microscopy and diffraction, and photoelectron spectroscopy to examine the chemical and structural or crystallographic properties of metal-semiconductor and semiconductor-semiconductor interfaces. Correlate the observed interface structure with electrical properties and with the method and conditions of preparation.

MILESTONES

Year 1: Use extended x-ray absorption fine structure (EXAFS) measurements to determine the chemical structure of Pd/Ge "epitaxial" ohmic contacts on GaAs.

Year 2: Compare structural and electrical properties of evaporated Al Schottky contacts with those produced by molecular beam deposition.

2. Metrology for Critical Semiconductor Processes

2.1 GOALS: Develop methods to evaluate the performance of process steps critical to the fabrication of submicrometer structures. Measurement methods required to determine correlations between processing steps and the nature of defects that are unimportant in present processes but which will be important in the future are of concern. Measure and characterize two-dimensional patterning of fine features in lithography, etching, growth, and doping or deposition, including alignment, resists, and light, x-ray, electron beam, or ion beam exposure sources. (See also section 2.3.) Investigate production-worthy metrology for new fabrication procedures that overcome existing material and process

constraints, and that eliminate or control random crystallographic and interfacial defects.

The approach will be to develop measurement techniques for evaluating and improving the understanding of the effects of process steps on the properties of the materials and devices fabricated, by measuring physical and electrical parameters such as film thickness, sheet resistance, dopant profiles, contact resistance, interface states and charge trapping, and deep-level defects. This includes measuring uniformity from wafer-to-wafer and batch-to-batch and measuring the numbers and effects of process-induced defects. Also included will be the development of measurement techniques and standard reference materials for controlling critical process steps to optimize or improve reliability, yield, defect density, cost, and throughput. Environmental effects, such as contamination and particulate control, will be a focus. (See also section 2.5.) The new measurement techniques will be in-process, wafer-level, and package-level tools for real-time quality control.

MILESTONES

Year 1: Demonstrate nondestructive measurement methods for quantifying damage induced by plasma and reactive ion etching in submicrometer structures.

Year 2: Develop and test physical and chemical models for the creation of process-induced defects and their elimination or deactivation by gettering and annealing during dry and low temperature (below 900°C) processing steps.

2.2 GOALS: Develop diagnostic tools, chemical reaction data, fluid dynamics models, and end-point detection methods for plasma-assisted film deposition and removal processes. Process models will be developed for plasma-assisted deposition and plasma, reactive ion, and reactive ion beam etching. These models will include both fundamental and applied experiments to understand and characterize the physics and chemistry of reactant absorption, creation of the product molecule or other physical structure, and, for etching, product molecule desorption.

Chemical vapor deposition (CVD), plasma deposition (PD), and plasma etching (PE) are important industrial processes for fabrication of semiconductor devices. These processes involve poorly understood, complex gas-phase reactions which control product quality and reproducibility. Current practice is usually based on empirical optimization of process parameters (e.g. temperature, pressure, gas composition, surface temperature, etc.) to obtain acceptable results without a detailed understanding of the chemistry involved. To exploit fully the capabilities offered by CVD, PD, PE and other processes and to improve product quality and meet new fabrication challenges it is necessary to develop microscopic descriptions of the mechanisms of gas phase as well as surface reactions. This requires diagnostic measurements of gas phase reactants, intermediates, products, and surface species. Laser-based diagnostic techniques (laser induced fluorescence, Raman spectroscopy, etc.) are most suited for detection of gaseous species and for measurement of gas phase kinetics relevant to deposition and etching processes. Tunable laser sources can also be used to improve film uniformity and deposition rates. Laser-enhanced CVD (LECVD) allows the selective photoexcitation of reactants.

LECVD also makes it possible to deposit films with improved dimensional control critical to the fabrication of submicrometer devices. Initial focus of this work will be on silane ($SiH_4$) and chloro-silane reactions. Later, reactions relevant to GaAs, InAs and other semiconductor systems will be investigated.

In CVD and PE, it is also important to understand the effect of energy and species transport on film deposition and removal processes. In these processes, chemical kinetic and transport phenomena are strongly coupled, and large concentration and temperature gradients exist in the reactors. Therefore, modelling of the entire process, with fully coupled kinetic and fluid dynamics, is a necessary tool to develop a basic understanding of the overall process and to optimize the operating parameters to achieve improved deposition and removal rates and film quality. Finally, surface analysis techniques will be developed to obtain composition and chemical state information in a variety of important electronic materials, including Si, GaAs, $SiO_2$, W, Mo, etc. For example, XPS, SIMS and ISS techniques will be used to characterize contaminating layers on films and to determine the appropriate removal temperature. Dynamic SIMS as well as depth-profiling modes of XPS and ISS will be applied to determine the chemistry of internal interfaces, especially the compositional gradients at interfaces. These techniques will be used to correlate film characteristics with changes effected via modification of gas phase reaction parameters.

MILESTONES

Year 1: Demonstrate the feasibility of utilizing laser-based diagnostic techniques for identification of important gas-phase reactions in CVD and PE. Use laser induced fluorescence to detect presence of $SiH_3$, $SiH_2$, $Si_2$, $SiCl_2$ and other intermediates of $SiH_4$ or chlorosilane decomposition.

Year 2: Develop a two-dimensional model for a generic CVD process geometry. This model will be used as a tool to optimize process geometry and operating conditions.

2.3 GOALS: Develop techniques for accurately measuring the critical dimensions of submicrometer features by optical and scanning electron microscopic techniques. Implementation of these techniques in the certification of new and improved feature-size standards and in recommended procedures for use in process verification by the semiconductor industry. The measurement techniques will include effects of the process procedure used to form the feature and the chemistry of the materials composing the feature; i.e. how the physical and chemical properties of the feature interact with the measuring electrical or optical beam.

Accurate measurement of the critical dimensions of microstructures on semiconductor devices is essential to the control of the production process and the attainment of useful yields. The difficulty of making these measurements to the required accuracy is being compounded as the next generation of microcircuits (ULSI) will have feature sizes below one micrometer. It is essential to develop the metrological tools, both theoretical and experimental, to put these measurements on a solid foundation.

For optical measurements we must develop the required electromagnetic models for microstructures whose size is of the order of the wavelength of light, confirm these models by experiment, and build and test an ultraviolet microscope capable of making the measurements to nanometer precision. For scanning electron microscope (SEM) measurements, we must use Monte Carlo calculations to model the electron beam interaction with the sample, detector, and chamber and again confirm the results by experiment with direct interferometry. Finally, in both these cases, the inverse problem must be solved (deducing the feature from the image rather than vice versa), suitable transfer standards must be developed, and the use of these standards in industry established.

MILESTONES

Year 1: Ultraviolet microscope fully operational

Year 2: Completion of electron/specimen interaction model

Later: Inverse Optical problem solved
Issuance of SEM linewidth standard

2.4 GOALS: Compile, evaluate, and generate fundamental chemical rates, transport parameters, and collision cross sections applicable to plasma processes and chemical vapor deposition. Develop generic computer model of such processes. Generate and evaluate fundamental rate data needed for modeling low-temperature glow-type electrical gas discharges for use in plasma etching reactors for processing semiconductor materials. Evaluate existing generic computer codes that can be used in modeling of gas-phase chemistry in glow discharges and which can be used for evaluating consistency among existing fundamental data on elementary processes and on observations of gas-discharge phenomena.

MILESTONES

Year 1: Compile data bases for electron collision cross sections, electron transport parameters, and reaction rate constants for fluorinated gases used in plasma etching reactors.

Year 2: Calculate chemical rate constants and electron transport parameters for selected gas mixtures proposed for or used in plasma chemical reactors, and evaluate consistency among electron collision cross sections, swarm, and dielectric strength data for these mixtures.

2.5 GOALS: Develop standards and diagnostic techniques for monitoring input gas streams for moisture and particulate content that provide real-time response and species selectivity. Apply such techniques for on-line measurement and control during the fabrication of submicrometer semiconductor devices and circuits. Develop sensors and particle detection and characterization tools for particulates and contaminants in gases, liquids, and on surfaces.

Moisture and particulates are the most important factors that contribute to device rejection and reduced productivity. Current humidity measurement techniques are limited to concentration levels above 1 ppm. New processes used for fabrication of submicrometer scale devices require measurements of humidity levels below 1 ppm. Measurements at such low concentrations would require development of new techniques utilizing optical methods. One such technique, which will be explored as part of this work, involves the use of a tunable diode laser for multipass infrared absorption measurements. This technique should provide reliable humidity measurements down to about 10 ppb level. The system accuracy and precision would be evaluated using a low dew point humidity generator, which is currently being constructed at NBS.

Particulate contamination has been another critical source of process inefficiency in microelectronics fabrication. This situation is expected to be further aggravated as the dimensions of microstructures are reduced to below a micrometer. Submicrometer particles, either introduced in the input gas stream or generated in some part of the process (such as by homogeneous gas-phase nucleation of $SiO_2$ particles), will represent a major source of device contamination and have to be measured and controlled at each step of the process. These techniques are to be utilized for on-line measurements and real-time control of fabrication processes. Stringent specifications and a priori measurements of these parameters are not sufficient to reduce the rejection rate of semiconductor devices, since moisture and particulates could be entrained in the transfer lines and introduced into the reactor. Therefore, on-line measurements are necessary to ensure high product quality.

MILESTONES

Year 1: Demonstrate feasibility of performing sub-ppm level humidity measurements in a flow system, using infrared laser absorption or other spectroscopic techniques.

Year 2: Demonstrate feasibility of performing single particle measurements in the submicrometer size range, in gas streams typical of those used in microelectronics processes.

2.6 Physics of Plasmas for Semiconductor Processing.

GOALS: Provide useful models to optimize plasma properties for specific semiconductor applications, including deposition, etching and control mechanisms; improve etch resolution via cryogenic plasmas. Predictive models require not only detailed plasma chemistry and kinetics, but also the basic physical properties of the plasma. The most important of such properties include the local energy distributions and densities of the charged particles in the plasma, and the electric field distribution.

MILESTONES

Year 1: Construct a discharge capable of operating over the range of RF frequencies and pressures used for plasma processing. Make preliminary electron and ion density diagnostics.

Year 2: Develop and evaluate methods for determining: charged particle and metastable state densities, electron energy and electric field distributions. Integrate computer modeling with plasma chemists. Begin low temperature development.

3. Metrology for Advanced Semiconductor Devices

APPROACH

The "device technologies" of practical importance in the 1990's will be submicrometer CMOS, high performance bipolar, merged MOS and bipolar, GaAs optoelectronics and microwave devices, and to a limited degree, quantum domain devices. Considering the structures and operation of these devices, two elements of commonality become evident; 1) micro dimensions (i.e., all are microstructures) and 2) high speed operation (ultrafast rise and fall times of signals, high frequency operation, or both). Metrology for these advanced semiconductor devices will require ultrahigh spatial resolution physical, electrical, and thermal analysis tools and ultra-high-speed instrumentation and signal sources deliverable at the chip or package level.

A third element of commonality is packaging complexity. The package serves three basic functions. They are 1) to provide a means for getting signals to and from the circuits/devices, 2) to provide a means of removing the heat generated by the operation of the circuits/devices, and 3) to protect the circuits/devices from the environment. The implementation of these functions for advanced semiconductor devices will require new packaging materials, concepts, and technologies. Ultra-high-speed devices will require innovative methods for getting signals to and from the chip. The power density of ultra-small, high density devices and circuits will require innovative methods and new materials for removing heat from the chip. The new packages must accomplish these functions while not sacrificing their own mechanical integrity. Severe metrological challenges exist to assure that the packaging achieves all of its functions.

3.1 GOALS: Develop methods for determining the critical physical, electrical, and optical properties of advanced semiconductor devices and circuits for wafer and chip level as well as for completed (packaged) devices and circuits.

The industry application of these measurements typically will depend on at which level the measurement is made. Measurements for completed devices are required for specification development and verification and are absolutely critical for the commerce between buyer and seller. Measurements at the wafer and chip level are sometimes used as above, but are usually used for feedback in device design and processing and for device and circuit model development and evaluation.

The critical needs for all levels of measurement will be for signals with ultra fast rise and fall times that are deliverable to and from the package or the chip. This will require active probes, "microwave-like" fixturing and signal propagation. Physical measurements will require submicrometer spatial resolution (horizontal and vertical). These will be accomplished by beam

analysis and excitation methods (SIMS, RBS, etc), advanced SEM and STEM techniques, and advanced optical methods. Advanced SEM analysis methods will be developed (both physical and electrical) and expertise in the other physical analysis methods will be maintained to permit the knowledgeable purchase of advanced physical analysis measurements.

MILESTONES

Year 1: Procure and bring into operation ultra high speed device and circuit analysis system. System will consist of commercial instrumentation and NBS fabricated instruments and fixtures.

Year 2: Develop advanced SEM techniques for impurity mapping (horizontal and vertical) with submicrometer resolution.

3.2 GOALS: Develop methods for determining critical device and circuit package related properties, such as signal propagation to and from the "chip", thermal control, and mechanical integrity.

Each of the three major functions of the package will be addressed in this element. Methods will be developed for assessing the capability of advanced devices for removing heat from the active devices and circuits. This will involve a combination of non-invasive infrared mapping methods and electrical characterization. It will also require fixturing in a variety of ambients, including fluid baths, still air, water cooled, and wind tunnels to simulate use conditions. The primary electrical problems are to ensure that the package does not cause distortion in signals to and from the active devices and circuits. High speed network analysis and innovative fixturing will be required to characterize the packages for potential electrical distortion and interference. (See also section 4.3 below.) The mechanical integrity of the package affects all functions of the package, thermal, electrical, and protection. New materials and materials bonding techniques will be required for advanced packages. Models and characterization techniques for the materials and their interfaces will be developed.

A key problem associated with the adhesion of metals to semiconducting substrates is the resulting residual stresses in the components due to thermal expansion mismatch between the metal and the substrate. These stresses can act in three main ways; they can cause the coating to crack or to delaminate from the substrate, or they can combine with stresses already present in the substrate to cause mechanical failure. The first two possibilities will be investigated through the construction of an holographic system to detect residual strains in the coatings. The coatings will be vacuum deposited and studied, in situ, using optical holography.

The mechanical stability of the substrate and its relationship to the pre-existing residual strain in the material before the coating is applied must also be investigated. Indentation tests as well as macroscopic crack growth techniques will be used to determine the susceptibility of GaAs substrates to mechanical and environmentally enhanced failure and to map out regions of residual stresses. These results will be correlated with x-ray topography and infrared microscopy data to determine the relationship between observed residual strains in GaAs wafers and residual stresses leading to failure.

Finally, after a coating is laid on the substrate, it is important to be able to measure the mechanical adhesion between the materials. Thermal waves and indentation techniques will be used to develop a method for measuring the adhesion of the coating to the substrate.

MILESTONES

Year 1: Procure high resolution thermal mapping system. Determine specific materials interface problems for advanced packages.

Year 2: Determine the coating adhesion to the substrate as functions of residual stresses in and hardness of the coating, and of processing variables of the substrate/coating system.

3.3 GOALS: Develop and verify fundamental physical models for phenomena critical to accurate advanced semiconductor device and circuit modeling.

Models based upon sound physical principles impact all areas of advanced device technology. As devices shrink in horizontal and vertical dimensions and employ materials with tailored band structures, classical approximations used in device modeling become invalid and quantum effects become more significant. This transition to more complex domains of operation is made more complex by the high electric fields, high current densities, and large gradients in carrier temperature present in submicrometer devices. The study of these effects requires that a set of models be developed which includes classical hydrodynamic models, modified hydrodynamic models including new physical effects, and Monte Carlo models. Development of these models requires expertise in numerical methods, device physics, and material properties/physics. Device and circuit models will aid in developing the metrology for advanced devices and are used for improving device and circuit designs.

MILESTONES

Year 1: Procure computational facilities required for models for advanced devices.

Year 2: Determine areas in greatest need of physical understanding for modeling submicrometer structures.

4. Process Metrology for Advanced Semiconductor Manufacturing

4.1 GOALS: Develop sophisticated quality control and yield enhancement procedures by combining artificial intelligence, statistical experimental design, and microelectronic test structures for manufacturing semiconductor circuits. Develop new electrical and statistical analysis techniques for assessing reproducibility, performance, and reliability of advanced microcircuits in a manufacturing environment.

Very often, results from a comprehensive test chip program are not used effectively or not used at all because of the quantity and complexity of the data and the lack of available expertise to evaluate the results and make

meaningful decisions. The goal of this effort is to apply Artificial Intelligence techniques to process development, manufacturing yield enhancement, and acceleration of technology transfer from the laboratory to the fabrication line of advanced VLSI/VHSIC microelectronic circuits. As a first step, an experimental expert system will be developed at NBS and exercised to demonstrate how such an approach can operate for analyzing selected portions of a VLSI process. In order to provide a data base for this expert system, a test chip and measurement program will be customized to provide data sensitive to various modes of operator, equipment, and process failure associated with replicating submicrometer polysilicon features with optical lithography and reactive ion etching. A knowledge base will be obtained from both test structure results and human experts and which will be compiled into a list of rules. An inference engine running on a small computer will be used to apply the measurement data to the knowledge base. The intended output of the first expert system will be a first-level differential diagnosis of the failure modes prevalent in the lithography process associated with defining a nominal one-micron single-level interconnection system. The experience gained from first expert system and associated test chip will be used as a basis for creating a more comprehensive system/test chip combination aimed at evaluating advanced VLSI/VHSIC process development.

NOTE: In order to perform this, fabrication services of a VLSI/VHSIC manufacturer will have to be secured via collaborative efforts with industry or via DOD involvement.

MILESTONES

Year 1: Develop and evaluate an expert system and selected test structures for characterizing the performance of near-micron lithography processes.

Year 2: Develop and evaluate an advanced deep reasoning expert system for submicrometer lithography system performance evaluation.

4.2 GOALS: Demonstrate value of sound experimental design and statistical process control as an alternative to expensive, after-the-fact procurement testing. Coordinate industry-wide round-robin experiments to improve measurement capability on the factory floor.

Interlaboratory experiments and standardization efforts will allow industry and government to make reliability predictions with greater confidence, promote more effective technical communications, permit sounder product-design decisions, and improve agreement of characterizations by vendor and user. The effort will be two fold: in the characterization of electromigration under pulsed conditions and of time-dependent dielectric breakdown (TDDB) of thin-film dielectrics. In each case, the effort will be designed to establish quantitatively the present status of such characterizations, to identify sources of measurement ambiguity, identify any critically-needed research efforts, and to develop measurement standards in these area, as appropriate.

Measurement deficiencies and ambiguities relative to critical failure mechanisms remain as serious obstacles to improving the performance, quality, and reliability of advanced VLSI/VHSIC microelectronic circuits. Two critical

failure mechanisms of such microelectronic circuits are electromigration of the interconnect metallization and TDDB of thin-film dielectrics used in the gates of MOS devices. Serious measurement and characterization gaps exist for the characterization of electromigration under pulsed conditions. In the absence of any consensus guides for current-density limits under pulsed conditions, existing dc guides have been used. A sense of urgency about this measurement deficiency is growing now as advances in the design of microelectronic circuits are creating pulsed current-density conditions in such circuits which exceed these dc limits. At the same time the prediction of the use life of thin-film dielectrics is a "black art". Considerable ambiguities remain in the existing data, the acceleration factors used, the models, and the characterization of dielectrics relative to TDDB.

NOTE: In order to perform this work, fabrication services of a VLSI/VHSIC manufacturer will have to be secured via collaborative efforts with industry or via DOD involvement.

MILESTONES

Year 1: Develop measurement capability for electromigration stress testing under pulsed current conditions; develop and evaluate special test structures for use in both interlaboratory experiments.

Year 2: Design, conduct, and analyze the results of interlaboratory experiments in electromigration and TDDB.

4.3 GOALS: Apply matrix methods to efficient functional testing of integrated circuits, accounting for effects of circuit topology and measurement error. Develop device measurements for very fast rise times. Extend these approaches into the manufacturing process to monitor process variables pertinent to items 4.1 and 4.2 above.

The critical problem of testing complex semiconductor devices will be addressed by extending and applying modeling and mathematical methods previously developed for analyzing the performance of simpler analog, digital, and mixed analog/digital circuits. Because of the large component count and number of circuit nodes contained in advanced ULSI devices and the relatively small number of external connections, it is likely that the use of built-in test circuits and circuit partitioning techniques will be required to develop improved functional tests from which overall performance can be deduced with high confidence. Matrix analysis methods have been shown to be applicable to this class of circuit testing, but are in a very early stage of development. Initial results are extremely encouraging. These methods will take into account the combined effects of circuit topology and measurement errors in estimating circuit component values and in predicting the performance of the circuit over the complete range of operating conditions.

As the dimensions of ULSI circuit components become smaller, the circuits operate faster. In addition, circuits are appearing which have lesser complexity but which are specifically optimized for high-speed operation. These bring the additional problems of measuring their speed and response times. Verifying impulse and step response times on the picosecond and sub-

picosecond scale with reliable, known accuracy requires new physical standards and related signal processing algorithms.

MILESTONES

Year 1: Development of circuit partitioning algorithms which will allow the extension of earlier analysis techniques to more complex analog circuits. Development of 10-100 picosecond rise time transfer standard.

Year 2: Development of strategies for evaluating nonlinear analog systems. Development of real-time, single-shot transient software algorithms.

5. Surface structure effects in film growth and properties

5.1 GOALS: Characterize film structure at the early stages of epitaxial film growth using forward scattering of photoelectrons and Auger electrons. Metal-semiconductor interfaces, which determine the properties of Schottky barriers, are of particular importance. Measure the structure and bonding of transition-metal atoms to silicon and gallium arsenide single-crystal surfaces. Measure surface segregation and interdiffusion in metal and semiconductor superlattices fabricated by molecular-beam epitaxy. Such properties are critical in ultrathin films where surface diffusion processes are very different from the bulk diffusion mechanisms for macroscopic materials. Finally measure the magnetic properties of ultrathin films.

MILESTONES

Year 1: Design and install new photoelectron spectrometer facility with ion scattering spectroscopy capability and film deposition equipment.

Year 2: Measure film atomic structure for transition metals deposited on silicon and gallium arsenide single-crystal surfaces.

5.2 GOALS: Characterize the physical structure and microcomposition of lithographic structures. Fabricate prototype lithographic structures (metal lines on different substrates; multilayer thin films; ion-implanted semiconductors). Surface measurement techniques with high-spatial resolution such as Auger-electron spectroscopy, secondary-ion mass spectroscopy, and scanning electron microscopy will be used to determine the physical structure and microcomposition of the test materials. New and improved algorithms will be needed to convert the measured signals to the desired quantities.

MILESTONES

Year 1: Specify, procure, and install high-resolution Auger-electron spectrometer and scanning electron microscope.

Year 2: Compare Auger-electron images from prototype test structures with predictions from new algorithms based on electron transport models.

5.3 GOALS: Characterize segregation and diffusion at interfaces on an atomic scale. Deposit metal films on silicon, germanium, and gallium arsenide, and obtain diffusion data by field-ion microscopy with near-atomic spatial resolution. Measure interdiffusion at the low temperatures required for device processing and operation and determine variations of parameters such as substrate geometry and impurity levels. Measure film properties such as nucleation, degree of crystallinity, and defect densities for deposition parameters such as substrate composition and structure, substrate temperature, vapor flux, and vapor purity.

MILESTONES

Year 1: Design and construct film deposition facility on field ion microscope.

Year 2: Determine segregation and interdiffusion at interfaces between silicon and transition-metal films for a range of film-deposition conditions.

5.4 GOALS: Determine atomic structure at buried thin-film interfaces. Use synchrotron radiation at the Brookhaven National Synchrotron Light Source with the techniques of x-ray standing waves (external total reflection and anomalous transmission methods) to measure non-destructively the atomic structure of the interface between thin-film layers. The registry of atomic layers between a substrate and a film is usually desired for high-quality epitaxial films but this has been very difficult to measure without modifying the specimen. Apply the above techniques to III-V and II-VI semiconductor compounds, oxides, and metals to provide the scientific basis for control of manufacturing processes.

MILESTONES

Year 1: Design and construct x-ray standing wave experimental facility.

Year 2: Apply x-ray standing wave technique to characterize nondestructively atomic structure at thin film interfaces between metals and compound semiconductors.

5.5 GOALS: Determine chemical states at interfaces. Use photoelectron spectroscopy with synchrotron radiation to determine the electronic structure and chemical states at interfaces when thin films are deposited on substrates. Deposit metal overlayers on semiconductors and determine the chemical state of reacted layers at the interface. Make prototype structural studies at the monolayer level of epitaxial insulating films.

MILESTONES

Year 1: Design and construct special chambers to perform photoelectron spectroscopy on semiconductor films at Brookhaven National Synchrotron Light Source.

Year 2: Identify chemical states at interfaces between epitaxial insulating films and semiconductor substrates.

5.6 Theoretical support for the above projects:

MILESTONES

Year 1: Develop theoretical methods for calculating the electronic structure of metals and semiconductors.

Year 2: Determine minimum-energy configurations for thin metal films on semiconductor substrates.

6. Mechanisms in surface processing

6.1 GOALS: Develop new optical and spectroscopic probes for characterizing surface-chemical processes during device processing. Use laser beams for surface processing (laser-assisted film growth, generation of radicals at surfaces, photo-carrier-induced chemistry, and fast heating) and as probes to identify chemical species on surfaces under processing conditions. Emphasize the characterization of non-equilibrium dynamics critical for low-temperature processing of semiconductor materials as well as for maintaining non-equilibrium structures during the desired service life of a device.

MILESTONES

Year 1: Design and install experimental chamber and laser equipment to investigate mechanisms of surface reactions.

Year 2: Determine mechanisms of laser-assisted growth of metal films on semiconductor substrates.

6.2 GOALS: Determine fundamental mechanisms in electron and photon beam lithography. Investigate radiation-induced surface reactions that are important for exposure of resists and deposition of films from organometallic compounds. Identify the mechanisms of such reactions and measure their cross sections.

MILESTONES

Year 1: Design and install experimental facility to detect atoms and molecules leaving a surface during lithographic processes.

Year 2: Measure cross sections for electron and photon induced reactions of organometallic resist compounds.

6.3 GOALS: Determine structural and topographic surface changes following surface processing. Use scanning tunneling microscopy, scanning electron microscopy, and standard surface techniques (low-energy electron diffraction, Auger-electron spectroscopy) for characterizing long-range

atomic ordering and short-range atomic disorder and defects following surface processing by ion, electron, or photon beams. Determine the mechanisms of these changes and the rates for specific conditions relevant to electronic materials processing. Examine the effects of these surface modifications on other surface processes.

MILESTONES

Year 1: Design and construct scanning tunneling microscope facility for measuring surface topography and defects.

Year 2: Determine changes in surface topography and defects following ion bombardment and effects on surface reactions of semiconductor materials.

6.4 Theoretical support for the above projects.

MILESTONES

Year 1: Develop theoretical methods for investigating molecular dynamics and reactions at surfaces.

Year 2: Calculate mechanisms and rates of prototype semiconductor processing reactions.

7. Standard reference data and materials

7.1 GOALS: Measure, compile, and evaluate critical data for (1) electronic and thin film material characterization and (2) chemical reactivity of transients in plasmas and on surfaces.

In (1), obtain data for the following parameters: electron attenuation lengths; matrix effects on elemental sensitivity factors; electron backscattering correction factors; the effects of specimen crystallinity on measured intensities for surface-characterization spectroscopies; and ion sputtering rates. In (2), kinetic and thermodynamic data are required to describe reactions in etching plasmas and on surfaces exposed to the plasmas. Measure, evaluate, and compile these and other important parameters in the form of computer-readable databases for efficient and convenient distribution. Develop improved algorithms for analysis of spectroscopic measurements. Incorporate these algorithms and the new data bases into new expert systems designed to improve the accuracy and efficiency of surface measurements.

MILESTONES

Year 1: Initiate compilations of critical data for characterization of electronic and thin film materials and for chemical reactivity in plasma processing.

Year 2: Produce computer-readable data bases for distribution.

7.2 Fabricate and characterize new SRMs for the calibration of instruments used for surface and interface characterization of electronic materials.

SRMs of the following types are needed: ion-implanted semiconductor materials with known concentrations and depth distributions; oxide thin film materials of known thickness; multilayer metal thin film materials of known thickness; superlattice materials; organic materials; prototype devices with known dimensions for calibration of length scales and spatial resolution of instruments; and multicomponent materials for calibration of instrument sensitivities.

7.3 Electronic Materials Data Center

GOAL: Establish a Standard Reference Data program to improve the quality and accessibility of data related to electronics materials. Address the data needs of three significant areas of the semiconductor industry; namely, materials, packaging materials and techniques, and manufacturing processes. The range of properties will include physical, chemical, electrical, magnetic, mechanical, corrosion and optical. Make available high quality scientific and technical data in database formats to help the industry explore new designs, improve the performance of packaged electronic devices and increase process efficiency.

MILESTONES:

Year 1: Establish database of physical, chemical and other data to support modeling of plasma manufacturing processes for electronic materials

Year 1: Establish database of physical, chemical, electrical, mechanical and other properties of silicon and gallium arsenide

Year 2: Establish database for III-V and II-VI compounds of interest

Year 2: Establish database of properties of electronic packaging materials

8. Advanced Analytical Techniques for Semiconductor Technology

8.1 High-energy radiation techniques

GOALS: New, extremely sensitive technology for the characterization of semiconductor materials and devices is a class of advanced analytical techniques which rely on high energy (MeV) particles in the primary (excitation) and/or secondary (analytical) streams. These techniques include Rutherford backscattering, particle-induced photon emission, nuclear reaction analysis, including hydrogen profiling, and accelerator mass spectrometry. All of these techniques make use of the same basic instrument, a tandem accelerator, with various experimental stations attached. In addition to the analytical techniques, the ion beam can be used for materials modification by high energy implantation and ion mixing. These advanced materials characterization techniques represent the state of the art.

MILESTONES

Year 1: Install and test tandem accelerator and demonstrate state-of-the-art Rutherford backscattering.

Year 2: Demonstrate hydrogen depth profiling by nuclear reaction analysis.

8.2 Ultratrace Bulk Materials Analysis

GOALS: The absolute amounts of impurities that must be determined in semiconductors are beyond the current state of the art. Ultratrace measurements will be applied to the special problems of advanced semiconductors. The existing techniques of Isotope Dilution Mass Spectrometry (IDMS), Inductively-Coupled Plasma with both Atomic Emission Spectroscopy and Mass Spectroscopy (ICP-AES and ICP-MS), Ion Chromatography (IC), and Neutron Activation Analysis (NAA) provide an unmatched combination of analytical tools for addressing this challenge. Capabilities in elemental analysis from ppb to below ppt in favorable cases will be further developed for semiconductor requirements.

MILESTONES

Year 1: Demonstrate quantitative dissolution techniques for the ultratrace analysis of key semiconductor materials and apply them with the appropriate analytical techniques. Where possible, compare these results with a second, nondestructive method.

Year 2: Produce one or more Standard Reference Materials (SRM's) of key semiconductor materials certified for elemental composition of the important ultratrace constituents.

8.3 Microanalysis Techniques at Nanometer Dimensions

GOALS: Semiconductor devices are reaching sub-micrometer dimensions. To perform chemical characterization of these structures and the processing steps necessary to produce them, advanced methods of microbeam analysis will be developed which can perform at the nanometer scale. Two specific techniques at the forefront of sub-micrometer analysis will be developed:

a) Analytical electron microscopy (AEM) provides chemical, morphological, and structural information down to a scale of about 30 - 50 nm with existing instrumentation. The new NBS-NIH Nanometer Analysis Facility, which will be on-line in the fall of 1987, offers the capability to extend the AEM technique to the scale of 1 - 10 nm. The current base of research in quantitative analytical electron microscopy and compositional mapping to the nanometer scale will be given particular emphasis on semiconductor characterization.

MILESTONES

Year 1: Prepare ultrathin semiconductor specimens for analytical electron microscopy and evaluate the practical limit of spatial resolution.

Year 2: With ultrathin specimens, study utility of electron energy loss spectrometry with parallel detection for compositional mapping at high spatial resolution.

b) Secondary ion mass spectrometry (SIMS) can be extended to the scale of 100 nm with high detection sensitivity through the use of pulsed ion beams derived from high brightness liquid metal ion sources in combination with time-of-flight (TOF) mass spectrometry for simultaneous detection of the total mass spectrum. This instrument will be used to explore high sensitivity/high spatial resolution analysis of semiconductors.

MILESTONES

Year 1: Determine detection limits and sensitivity/spatial resolution trade-offs for trace elements of interest in Si and GaAs/GaAlAs under high spatial resolution conditions.

Year 2: Develop quantitative analysis techniques and standards for TOF-SIMS applications to semiconductors.

LIGHTWAVE MEASUREMENT TECHNOLOGY
FY 1990 Initiative and Future Initiative
Project Plan

Introduction

Optical fibers are the transmission medium of choice for emerging terrestrial communications systems. The current world market for fibers and supporting components is $2.5B per year and is growing at about 25% per year. The U.S. accounts for $1.1B of this market. Growth of the U.S. market has slowed as the construction of long-distance lines has saturated but will pick up again as local area networks mature. Growth of the international market will remain at a high level, due to the continued installation of long distance lines in other countries and to the emergence of undersea lines and local area networks.

International competition to supply the world market is intense. The Japanese are on a par with the U.S. in fiber technology and are ahead and gaining in the technology of other key components, such as sources and detectors. The Europeans are proving to be effective competitors, too. U.S. success in the world market will require products of high quality, high performance, and low cost, all highly measurement-dependent aims. The measurement-intensive nature of this field is reflected in the fact that measurements account for 20% of the cost of manufacturing optical fiber cable.

Plans

NIST is using existing resources to develop measurement support for multimode and single-mode fibers. NIST is seeking additional resources for measurement development for related components and technologies in three groups, and this Project Plan addresses this expanded effort. Within the three groups are six projects. Each is described individually within this Project Plan.

| Group | Project | Measurement Support For |
|---|---|---|
| Group 1 | Project 1 | sources, detectors, and waveguides |
| Group 2 | Project 2 | modulators, demodulators, detectors |
| Group 3 | Project 3 | switches and amplifiers |
| | Project 4 | coherent communications, multiplexing |
| | Project 5 | hybrid and integrated optic circuits, materials characterization |
| | Project 6 | long-wavelength fibers, system performance |

A minimum of five initiatives will be necessary to fund measurement development for the three groups. Three of these initiatives have already been approved by Congress and are presently providing $1.85M per year of a needed $10M per year of new funding. A fourth initiative is presently part of the FY 1990 Budget of President Reagan, now before Congress. The fifth initiative is still in the proposal stage. The chart below shows the funding associated with each of these sources.

Funding in $M/year

| | Funding Required | Funding Provided FY 1987 Init. | FY 1988 Init. | FY 1989 Init. | Funding Requested FY 1990 Init. | Future Init. |
|---|---|---|---|---|---|---|
| Group 1 | 2.5 | 0.95 | | 0.40 | 1.15 | |
| Group 2 | 2.5 | | 0.50 | | 1.45 | 0.55 |
| Group 3 | 5.0 | | | | | 5.00 |
| | 10.0 | 0.95 | 0.50 | 0.40 | 2.60 | 5.55 |

CEEE chose to apply the funding from the FY 1988 initiative to Group 2 even though Group 1 was not yet fully funded. This decision was taken to enable work to begin on Group 2 earlier than would otherwise have been possible. Thereafter, CEEE returned to applying new funding to the groups in numerical order until each group is fully funded.

The following discussion describes the work that will be undertaken in each of the six projects. Representative planned accomplishments are also shown.

Project 1: Sources, Detectors, and Waveguides

Laser and light emitting diodes are the sources that create the light sent down optical fibers. Detectors capture the light at the receiving end and convert it to an electrical signal for subsequent processing. Waveguides are optical paths embedded in optically active materials. The waveguides channel light in desired directions and to transfer it from one path to another.

To provide measurement support for sources, NIST is using funding from the FY 1987 and FY 1989 initiatives to develop measurements for key diode characteristics including pulse width and speed, linewidth to 0.1 part per million (ppm), wavelength to 0.1 ppm and power output. With additional funding from the FY 1990 initiative, NIST will correlate key aspects of device design with linewidth and will measure linewidth and wavelength to closer tolerances in preparation for the coherent component of the work in Project 4 on Multiplexing and Coherent Communications. NIST will also develop measurements for diode spectral purity, modal noise, threshold current, and stability.

To provide measurement support for detectors, NIST is using funding from the FY 1987 and FY 1989 initiatives to develop measurements for a first set of parameters needed to characterize detectors, including spectral responsivity (sensitivity as a function of frequency), uniformity of response over the detector's surface, and speed and linearity of response. The additional funding requested in the FY 1990 initiative will enable expansion to include measurements for electronic noise in detectors, characterization of detector/amplifier packages, and fabrication of special detectors to enable correlation of key aspects of design with noise performance and sensitivity. Noise measurements are especially important since improved noise performance reduces errors in transmission and enables reduction of the numbers of repeaters (re-amplification stations) along an optical fiber communications line. That reduction in turn reduces the cost and increases the reliability of the line.



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To support waveguides, NIST is using funding from the FY 1987 and FY 1989 initiatives to develop measurements and theory for attenuation and mutual coupling in the guides, and measurements for index profile. The additional funding from the FY 1990 initiative will be applied to develop time-domain reflectometry techniques that will enable determining the performance and defects in optical waveguides. Also, NIST will extend its measurement development beyond the present materials supported, glass and lithium niobate, to compound semiconductors.

Finally, the FY 1990 initiative will support construction of a facility for the preparation of optoelectronic materials and devices needed for measurement development for sources, detectors, and waveguides.

FY 1990 Accomplishments (FY 1990 Initiative):

Develop models and a laboratory system to support measurement development for noise in the detectors that receive lightwave signals sent through optical fibers. Noise in detectors is a major factor degrading the performance, and thus the marketplace competitiveness, of fiber optic systems.

Develop a laboratory system for use in developing optical time-domain reflectometry measurements for characterizing the integrated waveguide structures that control the paths of lightwaves in fiber optic systems. Special measurements are needed to support emergence of improved waveguide products.

Project 2: Modulators, Demodulators, and Couplers

Programmatic Description:

Modulators place information on the lightwaves that are sent down optical fibers. Demodulators remove that information at the point of reception. The rate at which modulators and demodulators perform their functions is one of several factors that determine the information handling capacity of a fiber optic system. Couplers join optical fibers together and must transfer light with minimum loss to keep signal strength strong. They require mechanical precision and special optical interface technology to perform their function efficiently.

For measurement support for modulators and demodulators, NIST is presently applying the funding from the FY 1988 initiative to develop measurements for the dominant method of modulation, pulse code modulation. Special emphasis is being given to measurements for characterizing discrete lithium niobate modulators, with focus on modulation depth and modulation speed. The FY 1990 initiative will support expansion to additional types of pulse code modulators: integrated compound-semiconductor modulators, and integrated superlattice compound-semiconductor modulators. Finally, a small amount of additional funding from the proposed future initiative will be used to accelerate the work on pulse code modulation and to enable expanding this project to include coherent modulation for emerging ultra-high-performance systems. This work ties into and supports the coherent component of Project 4 on Multiplexing and Coherent Communications.

For couplers, NIST is using funding from the FY 1988 initiative to support development of measurements for losses in the "passive" couplers for joining both single-mode optical fibers and multimode optical fibers. The FY 1990 increase will enable expanding the work on "passive" couplers to include measurements for bandwidth and coupling geometry. Finally, a proposed future initiative will enable expansion and acceleration of the work on "passive" couplers and later extension to "active" couplers. Active couplers incorporate active devices, such as sources and amplifiers, right into the structures of couplers. The work on active couplers ties into and supports the work in Project 3 on Switches and Amplifiers.

FY 1991 Accomplishment (FY 1990 Initiative):[1]

Develop laboratory system to support measurements of bandwidth degradation by couplers. Couplers must meet rigid requirements for bandwidth preservation to prevent degradation of system performance.

Year 1 Accomplishment (Future Initiative):

Develop laboratory system for characterizing coherent modulators. Coherent modulators must achieve high performance levels to enable coherent systems to achieve high information rates.

Interactions with Industry:

For this project NIST anticipates: industrial research associates, collaborative research projects with industry and universities (e.g., work with Colorado State University, University of Illinois, and Bell Labs on chemical beam methods for sample preparation), contributed samples to support measurement development, and joint standards development with the Electronic Industries Association.

Project 3: Switches and Amplifiers

Programmatic Description:

Optical switches control the passage and direction of signals through an optical communications system. Optical amplifiers restore the strength of weak optical signals that must travel long distances or that must be subdivided many times for the multiple branches of a local area network.

For switches, NIST will focus on measurement of switching times, with resolution to 10 picoseconds initially, and later to 1 picosecond. The speed of switches is one of the key factors limiting the rate of information handling by an optical communications system. After addressing switching time, NIST will develop measurements for other important parameters of switches, such as efficiency and on/off voltages. For amplifiers, NIST will

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[1]Because of first-year costs for equipment and facilities, first-year funding will be focused on Project 1 until the second year when part of Project 2 can be funded also. Thus there is no first-year FY 1990 milestone for Project 2.

focus on measurements of bandwidth and noise first, then gain, heterodyne responsivity, and linearity.

Year 1 Accomplishments (Future Initiative):

Design and build a laboratory system for use in developing measurements of the speed of optical switches, with 10-picosecond resolution. U.S. industry will use this measurement capability to achieve high optical switching speeds. High speeds are essential for high rates of information transfer in competitive optical systems.

Design and build a laboratory system for use in developing measurements of bandwidth, noise, and gain in optical amplifiers. These are the principal parameters that determine amplifier performance.

Interactions with Industry:

For this project NIST anticipates: industrial research associates, collaborative research projects with industry and universities, contributed samples to support measurement development, and joint standards development with the Electronic Industries Association.

Project 4: Multiplexing and Coherent Communications

Program Description:

Multiplexing and coherent techniques enable increasing the amount of information sent through an optical fiber communications system. Multiplexing means combining different optical signals together at the point of transmission for more efficiently handling. That process is reversed at the point of reception where the signals are separated from each other. Coherent techniques enable many different signals, each of which may contain many multiplexed signals, to travel down an optical fiber simultaneously and to be separated readily at the receiving end by tuning, much as a radio or television set tunes. Coherent techniques also enable increasing the signal-to-noise ratio by about 20 dB (100 times better). This improvement reduces the number of repeaters (amplification stations) required in long-distance lines. The reduction of the number of repeaters lowers system costs and increases system reliability. High system reliability is particularly important for planned transoceanic systems since repairs of repeaters will be extremely expensive. Coherent techniques will also be important for local area networks where signal-to-noise ratio will be degraded by repeated subdivision of signals for the multiple branches of the networks.

The performance of a coherent system requires precise control of the frequency and phase of the light in the system. To help achieve this control, NIST will develop absolute frequency standards for use at several wavelengths in the vicinity of 1.3 and 1.55 micrometers. Related transfer standards will be developed to enable delivery to industry. Also, highly accurate measurements for phase noise will be developed. For multiplexers, NIST will focus first on electrical techniques for multiplexing. Then NIST will move quickly to optical techniques using discrete components and finally to optical techniques using integrated-circuit components. Wavelength-division multiplexing will be the key technique addressed. Key parameters that require

measurement support include cross-talk, attenuation, coupling efficiency, bandwidth, and polarization.

Year 1 Accomplishments (Future Initiative):

Develop measurement methods for characterizing a key performance parameter (cross-talk) in wavelength-division multiplexers. Multiplexers combine multiple signals together to increase the information handling capacity of optical fiber systems. High performance is essential for competitive systems.

Develop first laboratory implementation of a frequency standard for coherent communications systems operating at 1.3 micrometers. Coherent techniques can improve system performance by providing better noise tolerance. They require better frequency references than are now available before U.S. industry can make them a competitive reality.

Interactions with Industry:

For this project NIST anticipates: industrial research associates, collaborative research projects with industry and universities, contributed samples to support measurement development, and joint standards development with the Electronic Industries Association.

Project 5: Materials Characterization and Integrated-Optic Circuits

Programmatic Description:

Lack of measurement methods and verified data for characterizing electrically active materials is hampering the development and application of new optoelectronic devices. Both discrete and integrated-optic devices are affected, but the need for materials data is especially critical for integrated-optic circuits. This project will develop the measurement methods and data required to meet that need, focusing both on lithium niobate and compound semiconductors. Lithium niobate and glass will be used in discrete components. Compound semiconductors will be used in both discrete components and integrated-optic circuits.

For lithium niobate, measurement techniques will be developed for surface roughness and for electro-optic, acousto-optic, magneto-optic, and thermo-optic properties. For glass, measurement techniques will be developed for attenuation, coupling losses, cross-talk, and switching efficiency. For compound semiconductors, measurements will be developed for attenuation, coupling losses, bandwidth, cross-talk, and switching efficiency.

Year 1 Accomplishments (Future Initiative):

Develop a laboratory system for measuring the electro-optic coefficients of optical materials, as the basis for published reference data for industry. Lack of accurate data on optical materials is retarding U.S. industry's development of both discrete optical devices and integrated-optic circuits.

Develop a first method for attenuation measurement in integrated-optic circuits. Better measurements of attenuation will aid U.S. industry in overcoming present high attenuation levels. These high levels are inhibiting

the emergence of powerful, low-cost integrated-optic circuits as competitive products.

Interactions with Industry:

For this project NIST anticipates: industrial research associates, collaborative research projects with industry and universities especially on integrated optics, contributed materials samples and integrated optic devices to support measurement development, and joint standards development with the Electronic Industries Association.

Project 6: Long-Wavelength Fibers and System Performance Measures

Programmatic Description:

Current optical fibers, based on silicon dioxide, have attenuation as low as 0.2 dB per kilometer. New long-wavelength fibers, based on halides, are under development. They offer reduced levels of attenuation levels of 0.001 to 0.002 dB per kilometer. These fibers will operate at wavelengths of 1.8 to 3.0 micrometers, compared to the present 1.3 and 1.55 micrometer wavelengths of silicon dioxide fibers. The new long-wavelength fibers are important to long-distance lines, especially transoceanic lines, since they will reduce the number of repeaters (amplification stations) required by the line. This reduction will increase system reliability and reduce system cost.

As the performance and complexity of optical fiber systems increases, the industry will need more powerful methods for verifying and maintaining that performance. In particular, industry will need objective measures applicable both to sophisticated long-distance lines, including the transoceanic lines, and to expansive local area networks.

For the long-wavelength fibers, NIST will develop special methods for determining their unusually low levels of attenuation. These methods will affect R&D, marketing, and design of systems employing the fibers. As these fibers come into service, NIST will have to provide special methods for characterizing their numerical aperture, spot size, and cut-off wavelength.

For system performance measures, NIST will develop accurate measurements of bit error rates. First, NIST will focus on detailed studies aimed at proper interpretation of "eye diagrams", a sensitive analog technique for qualitatively assessing bit error rates. Later, NIST will development more comprehensive digital techniques that will give precise quantitative assessments of bit error rates in optical fiber systems.

Year 2 Accomplishments (Future Initiative):[2]

Design and build a laboratory system for developing measurements for attenuation in ultra-low-loss fibers operating at long wavelengths (1.8 to 3.0 micrometers).

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[2]Because of first-year costs for equipment and facilities, funding for Project 6 will not begin until the second year.

Design a system for critical measurement and interpretation of "eye diagrams" used for evaluating the bit error rate, a major parameter for characterizing the performance of fiber-optic systems.

Interactions with Industry:

For this project NIST anticipates: industrial research associates, collaborative research projects with industry and universities, contributed samples of long-wavelength fibers to support measurement development, contributed test equipment for systems performance measures, and joint standards development with the Electronic Industries Association.

# MICROWAVE MEASUREMENT TECHNOLOGY
## Future Initiative
## Project Plan

Summary

Microwave systems are critical to the national economy, the national safety, and the national security. The U.S. relies on high performance microwave systems to provide corporate communications, to land airplanes safely, to warn of weather disasters, to conduct international affairs of state, and to defend the nation. In these capacities, microwave systems serve as the eyes of the nation and the backbone of its worldwide communications networks.

The amount of microwave equipment that these and other microwave services require is vast and growing. Present U.S. shipments of microwave equipment are estimated at $35B per year and account for nearly 1/6 of all electronic equipment, systems, and components shipped in the U.S., valued at $223B for 1987. Worldwide shipments of microwave equipment are estimated at $81B per year and are expected to reach $143B per year in the year 2000 (1988 dollars).

The growth in the worldwide market for microwave systems arises from both traditional applications, like those mentioned above, and emerging applications. Emerging applications include: microwave electronics for high definition television (HDTV), for fiber optic communications, and for computer circuitry; vision systems for robots; on-board wind-shear detection systems for airplanes; collision-avoidance radar for automobiles; direct broadcast systems employing satellites; and local communications and radar systems for industrial and corporate applications.

The nations that will win the expanding worldwide market must successfully pursue three revolutionary changes in microwave electronics: extraordinary performance levels; integration; and higher frequencies.

Extraordinary performance levels mean improving speed, signal quality, sensitivity, versatility, and flexibility. These improvements are needed to increase information handling capacity and to open new applications areas.

Integration means integrating microwave electronic devices with each other, with optoelectronic devices, and with antennas. Integration is necessary to reduce the size, cost, and weight of microwave systems and to increase their power and versatility.

Exploitation of the higher frequencies means opening frequencies in the region from 30 GHz to 1000 GHz to greater use, or to first use, in order to gain access to the additional spectral space and special properties that they offer.

These changes in microwave technology are just as significant as those that took place in semiconductor technology when integrated circuits replaced transistors and tubes. In fact, that is exactly what is in happening now for microwave technology. These are exciting changes. They will ultimately lead to powerful new products, such as entire microwave systems on individual wafers a few inches in diameter. Each wafer will contain an electronically steerable antenna and integrated electronics for transmission, reception, and

signal processing. Such "microwave systems on a chip" will support robot vision, automobile radar, and other applications.

However, the promises implicit in advanced microwave technology cannot be realized without dramatic improvements in measurement support. NIST has long been aware of the shortfall in its resources to meet industry's measurement needs. Industry executives, through the IEEE's Committee to Promote National Microwave Standards and through the National Conference of Standards Laboratories, have decried the lack of NIST measurement support for industry, have surveyed the needs, and have spelled out the action needed from NIST.

NIST's response is this initiative. NIST proposes to build an expanded microwave measurement technology program in order to provide advanced measurement support for high performance microwave components in three classes: (1) individual components, including antennas, for 1-100 GHz; (2) integrated circuits and integrated antennas for 1-100 GHz; and (3) integrated circuits and integrated antennas for 100-1000 GHz.

This expanded measurement program will provide the measurement capability needed to accelerate R&D toward new products, to improve quality control during manufacturing, to provide the basis for voluntary industry standards for compatibility and other aims, to support the specification and procurement of microwave products, to improve access of U.S. products to international markets, and to assure U.S. international competitiveness in one of the largest segments of the world market for electronic products.

Organization of this Document

In this document, the following topics are discussed:

(1) Definition of Microwaves
clarification of terminology

(2) Capabilities and Limitations of Microwaves
technical description of the capabilities and limitations of microwaves, needed for understanding the following material

(3) Microwave Electronics Markets
the size and nature of microwave markets, and the expanded or new services demanded by those markets

(4) Technical Goals for Industry in Response to Marketplace Demands
the technical goals that industry must achieve if its products are to meet the demands of the marketplace

(5) NIST Measurement Support for Industry's Technical Goals
the measurement capability that NIST must develop to enable industry to achieve its technical goals

Definition of Microwaves

Microwaves are radiated electromagnetic energy just like the radio waves used for radio and television broadcasts, except that microwaves are about 1000 times higher in frequency. Lightwaves are similar to microwaves, but are even higher in frequency, about another 1000 times higher.

Overview of Frequency Spectrum

| | | | |
|---|---|---|---|
| Megahertz (MHz) = $10^6$ Hz | medium frequency waves | | a.m. radio |
| | very high frequency waves | | f.m. radio, TV, etc. |
| | ultra high frequency waves | | TV, other |
| Gigahertz (GHz) = $10^9$ Hz | centimeter waves | ] | MICROWAVES |
| | millimeter waves | | |
| | sub-millimeter waves | | |
| Terahertz (THz) = $10^{12}$ Hz | infrared light | | |
| | visible light | | |

Microwaves have frequencies in the range of 1-1000 GHz.[1] Most microwave systems today operate in the range of 1-30 GHz; but frequencies up to 100 GHz are increasingly used, and applications to 300 GHz and even to 1000 GHz are in the offing. Microwaves get their name from the fact that they travel through

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[1]The term "microwaves" is sometimes used to represent frequencies in the range of 1-30 GHz. Here "microwaves" will be used to represent all frequencies in the range of 1-1000 GHz. The terms centimeter waves, millimeter waves, and sub-millimeter waves will be used to distinguish among the types of microwaves.

the atmosphere as closely spaced waves. If microwaves could be made visible, they would look like a succession of small ripples, much like the ripples that move across a pond when a rock is dropped in it. The distance from one ripple to another in a microwave is called the wavelength and is usually measured in centimeters or millimeters, hence the terms "centimeter waves" and "millimeter waves" for key portions of the microwave spectrum.

Microwaves are an important part of the frequency spectrum available for our use. This frequency spectrum is limited in capacity because a given frequency cannot be used by two systems at the same time in the same location without mutual interference. The demand for certain frequencies within the spectrum is high, so many conflicts arise. Often these conflicts are international in scope and must be resolved by international bodies.[2]

Communication systems that employ microwaves consist of many electronic components. At the transmission end of a microwave system, electronic devices create and amplify the microwave beam and place information on it. Antennas radiate the beam toward the receiving area. At the receiving end, other antennas capture the incoming beam and other electronic devices remove the information from it. All of these components must work well to preserve the fidelity of the information on the beam. The measurements developed for microwave systems must assure that all functions necessary to accomplish this goal work correctly.

Radar systems work much like communication systems except that they use the same antenna for transmission and reception and they send out a pulsed beam of microwaves, rather than a continuous beam.

Capabilities and Limitations of Microwaves

Microwaves have inherent capabilities and limitations relative to radio waves of lower frequency. The degree to which the capabilities can be realized in real microwave electronics depends on the development of sophisticated microwave technology that is highly measurement intensive.

High information capacity: Microwaves can carry very large amounts of information. This capability is the result of the fact that microwaves have a very high frequency. All radio waves, including microwaves, can carry information in proportion to their frequency. For example, microwaves can carry 1000 times more information than radio waves used for a.m. and f.m. radio. Put another way, one microwave signal can carry all of the program material of 1000 a.m. radio stations simultaneously. This high information capacity is important both to telecommunications applications and to signal processing applications.

Line-of-sight transmission: When microwaves are radiated by antennas, they travel in a straight, line-of-sight manner. This is true because microwaves, unlike radio waves of lower frequency, pass right through the ionosphere,

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[2]The World Administrative Radio Conference meets every four years under the aegis of the International Telecommunications Union to make the frequency allocations, and the International Frequency Registration Board keeps track of the allocations.

which is the electrically charged atmospheric layer surrounding the earth. For this reason, microwaves cannot work their way around the globe by bouncing back and forth between the earth and the ionosphere, as radio waves of lower frequency can do. Instead, microwaves must be relayed along the surface of the earth from one microwave tower to another, or they must be transmitted to satellites that retransmit them downward to desired locations or that relay them to other satellites for retransmission downward. This line-of-sight characteristic is a limitation for some applications. For other applications, it is an advantage: it helps prevent interference among different microwave systems operating on the same frequency.

Highly focused: Microwaves can be focused into narrow beams much more easily than radio waves of lower frequency. In this sense microwaves approach the characteristics of light; light is readily focused by reflectors like those in flashlights. Because microwaves can be focused, their energy can be delivered to small nearby receiving antennas or to entire geographical areas, such as entire states, from remote satellites. Also, because of focusing, two or more microwave beams can be directed to adjacent areas without mutual interference, even if they operate on the same frequency. This characteristic improves efficiency in the use of the microwave portion of the frequency spectrum.

Small antennas: The high frequencies of microwaves reduce the size of the antennas needed to achieve a given degree of focusing. This fact reduces the cost of microwave systems and increases the diversity of applications that they can serve. For example, the relatively small size of microwave antennas makes them suitable for roof-top mounting for corporate communications systems. The size advantage also facilitates mobile applications in automobiles, airplanes, satellites, and space vehicles. The size reduction is particularly important for the design of highly focused antennas, since antennas with high focusing are larger than those with less focusing at a given frequency. Even very highly focused microwave antennas can be tolerable in size (several meters); antennas with comparable focusing at lower frequencies would be impossibly large.

Atmospheric interactions: The higher frequencies of the microwave family (the millimeter-wave and sub-millimeter-wave frequencies) interact more with the atmosphere than do radio waves of lower frequency. This interaction limits the distances over which these microwaves can travel through the atmosphere, a problem for some applications. For other applications, this interaction is an asset: it enables the use of microwaves to sense weather conditions that radio waves of lower frequency cannot "see"; and it enables limiting a transmission to a controlled distance to reduce unwanted reception by nearby users or unwanted interference with them when they are operating on the same frequency. This characteristic is particularly important when using millimeter waves for local applications such as local communications systems or local radar systems for monitoring moving objects. In free space, atmospheric interactions are not a problem, even for satellite-to-satellite communications, since satellites orbit well above the atmosphere.

Metal/earth interactions: Microwaves interact more sensitively with conducting objects, including the earth, than do radio waves of lower frequency. Therefore, they are effective for radar, navigation, guidance, and remote sensing (geological, agricultural, and weather sensing).

High spatial resolution: The higher frequencies in the microwave spectrum provide high spatial resolution. High resolution is particularly important for radar systems since it allows them to "see" objects more clearly and thus to identify them more accurately.

Optoelectronic technology: Microwave technology can be integrated with optoelectronic technology to provide powerful capabilities that are not achievable by either technology alone. For example, microwave technology is now being used to place information on lightwaves in experimental optical fiber systems. This new approach has produced the highest information rates yet achieved in optical fiber systems.[3] Conversely, optical fibers show promise for use in large microwave antennas; and embedded optical waveguides show promise for use in integrated microwave antennas and in microwave satellite systems.

Note in the above discussion that microwaves are repeatedly associated with smallness: small waves, measured in centimeters and millimeters; small antennas; and fine scales of resolution for radar. All of these characteristics derive from the high frequencies of microwaves. However, as noted earlier, the special properties of microwaves can only be fully exploited with sophisticated microwave technology, and that technology is very measurement intensive.

## Microwave Electronics Markets

### U.S. Outlook

U.S. shipments of microwave equipment are estimated at $35B for 1988.[4] Microwave equipment represents nearly 1/6 of all U.S. shipments of electronic equipment, systems, and components, valued at $223B in 1987.[5] Only one other equipment category has greater shipments: computers and their peripherals.

Most microwave equipment falls in the category "radio communications and detection equipment" (SIC Code 3662)[6]. For this reason, the performance of

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[3]"Lasers" in Fiber Optic News, page 4 (April 4, 1988). The potential for microwave electronics in fiber optic systems is further discussed by Jeff Montgomery and John Ryan, "Leap Seen for Microwave Fiber-Optics", Microwaves & RF, Vol. 26, No. 6, p. 53 (June, 1987).

[4]Microwave equipment shipments are not tracked as an independent data category in the current Standard Industrial Classification (SIC) System of the U.S., so the exact levels are difficult to determine. The figure shown here is based on an estimate that U.S. shipments represent about 95% of those for North America as a whole. The North American production is estimated as $36.8M for 1988 by Jeff D. Montgomery of ElectroniCast Corporation in "Microwaves to 2013", Microwave Journal, Vol. 31, No. 9, pp. 259-272 (September, 1988).

[5]1988 Electronic Market Data Book by the Electronic Industries Association Marketing Services Department, p. iii.

[6]SIC means Standard Industry Classification System.

this category provides the best documented estimator we have of the outlook for U.S. shipments of microwave equipment. U.S. shipments of all equipment in this category were valued at $54B in 1987 and are expected to grow at 4% in 1989 and at 5% per year for the following five years in real terms (exclusive of inflation), according to the Department of Commerce.[7] If these rates of growth are applied to the microwave content of U.S. shipments ($35B in 1988) through 1994, and if the 5% rate continues rate continues to the year 2000, then the following levels of microwave shipments in constant 1988 dollars will result:

Projected Growth of U.S. Microwave Equipment Shipments

| | | Billions of Dollars | | |
|---|---|---|---|---|
| | | 1988 | 1994 | 2000 |
| Constant 1988 dollars | (no inflation) | 35 | 46 | 62 |

The enormous size of U.S. shipments of microwave equipment reflects the broad range of services that microwave systems already provide: communications; navigation; radar; guidance; remote sensing (geological, agricultural, and weather); electronic warfare; test and measurement; industrial applications; consumer applications; and others. The demand for new or emerging services will keep the shipments of microwave equipment high. Examples of new or emerging services include: on-board wind shear detection systems for airplanes; improved radar systems for weather forecasting; collision avoidance radar systems for automobiles[8]; low-power high-speed communications systems for local environments[9]; local radar systems for monitoring and controlling moving objects[10]; vision and control systems for robotics; high speed computer circuits; signal processing for high speed fiber optic communications systems; signal processing for high definition television (HDTV); and local bypass facilities for corporate communications.[11] Other new or emerging applications

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[7] 1989 U.S. Industrial Outlook of the U.S. Department of Commerce, pp. 27-1 to 27-3.

[8] West Germany is in the lead. AEG Ag has announced imminent introduction of an integrated circuit chip containing a millimeter-wave receiver, with a projected cost as low as $15, suitable for communications systems and automobile radar.

[9] Japan's Key Technologies Research & Development Center is investing 45 million yen to develop this flexible new communications product for frequencies from 10 kHz to 1000 GHz.

[10] Japan's Key Technologies Research & Development Center is investing 120 million yen in developing remote monitoring and control systems using millimeter waves capable of handling 100 units of moving objects in natural environments within 2 kilometer radius to assure safe functioning.

[11] The facility bypass networks bypass local public telephone networks to achieve one or more aims: "reduce costs, improve service quality, and offer greater security, reliability, and service flexibility". They are usually implemented with microwave systems since installation of custom cable systems

require satellites. Examples include: television receive-only systems associated with direct broadcast satellite (DBS) service[12]; satellite mobile systems; direct business use of satellites for video programming; and end-to-end facility bypass networks. The last two are already major industries. Many of the others have the potential to become so.

U.S. Government Purchases

Of the $54B of equipment in the category "radio communication and detection equipment" (SIC Code 3662), $26B or 48% was purchased by the U.S. Government. Of that $26B, $23B or 43% of the $54B, was purchased by the Department of Defense, according to the Department of Commerce.[13] These figures provide the best documented estimators we have of the fraction of microwave equipment purchased by the Government.

While the DOD is expected to remain the largest Government purchaser of microwave equipment, other Government agencies are increasingly involved in making, stimulating, or approving major uses of microwave equipment. The Departments of Transportation, Commerce, and State, and the Federal Communications Commission and the National Aeronautics and Space Administration provide examples:

> The Department of Transportation (FAA) is currently participating in a $5-6B procurement of microwave equipment to upgrade the microwave systems at 100 U.S. airports. The new systems include: (1) communications systems for exchange of information between airplanes and control towers; (2) landing systems for aircraft; (3) radar systems for monitoring weather; and (4) radar systems for monitoring the movement of airplanes in the air and on the ground.[14]
>
> The Department of Commerce is the principal partner in a related three-agency $0.5B procurement for NEXRAD, the next generation of weather radar. By the mid 1990s, 175 NEXRAD systems are slated for installation.[15]

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is too expensive and far less flexible. The Department of Commerce indicates, in a review of studies of the subject, that "16-29 percent of large-volume telephone company customers are bypassing their local telephone companies". End-to-end facility bypass networks bypass both local and long distance lines of public telephone networks. 1988 U.S. Industrial Outlook of the U.S. Department of Commerce, p. 33-3.

[12]Japan is in the lead.

[13]1989 U.S. Industrial Outlook of the U.S. Department of Commerce, p. 27-1.

[14]Information provided by the FAA. The system is described in the National Airspace System Plan, Federal Aviation Administration, U.S. Department of Commerce (June, 1988). A discussion of the new system appears in "Why Tomorrow's Skies will be a Whole Lot Safer", Business Week, pp. 99, 102 (September 5, 1988).

[15]Performance, Unisys Defense Systems Issue, p. 5 (Spring/Summer, 1988).

The Department of Transportation (FAA) is requiring that wind shear detection systems be installed on 3600 jetliners within four years. While costs vary with the type of aircraft, an estimate of $50,000 per aircraft has been mentioned leading to a total cost of $0.2B.[16] FAA is not specifying the technology to be used; the marketplace will decide. Microwave radar, laser radar, and passive infrared systems are the primary candidates for forward looking detection.[17]

The Department of State has issued a request for proposals for a new worldwide telecommunications network that will cost up to $0.7B. It will contain a mix of microwave and fiber optic communications technologies and computers.[18]

The Federal Communications Commission has just approved the launching of 23 new communications satellites, valued at $4B.[19]

The National Aeronautics and Space Administration, in cooperation with the National Oceanic and Atmospheric Administration of the Department of Commerce, is actively evaluating the merit and design of an Earth Observing System, composed of four to six satellites to monitor long-term changes in the earth's atmosphere, magnetic field, geology, etc. The project is collaborative with Japan and the European Community. U.S. costs for the system would be $2B to $4B over ten years. The system would rely critically on advanced microwave and optical equipment.

World Outlook

The world market for microwave equipment is estimated to be 2.1 to 2.5 times the size of the U.S. market alone.[20] If we assume the median value of 2.3 and

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[16]"Wind-Shear Devices to Be Required on Jets", Washington Post, p. A19 (September 27, 1988).

[17]FAA and NASA are jointly investing $24.8M over five years (beginning in 1987) to stimulate development of advanced wind shear detection systems in their Forward Looking Technology Program. The systems are described in Airborne Wind Shear Detection and Warning Systems: First Combined Manufacturers' and Technologists' Conference, Federal Aviation Administration, U.S. Department of Transportation, and National Aeronautics and Space Administration (January, 1988).

[18]The project is described in Department of State Telecommunications Network, Request for Proposal by the U.S. Department of State (October, 1988).

[19]"FCC Okays $4B in Satellite Launchings", Electronic Engineering Times, p. 38 (January 16, 1989).

[20]Again, good figures are lacking, but estimates can be made based on estimates of world market sizes for categories containing a lot of microwave equipment. Dick Anderson, Vice President and General Manager of the Microwave and Communications Group of Hewlett-Packard, has provided one of those estimates in a talk at Test and Measurement Trends and Technologies -

a real growth rate of 4% for 1989 and 5% for the following five years, identical to the pattern projected by DOC for the next six years for the U.S. alone, and if the 5% rate is further assumed to apply to the year 2000, then the following levels of microwave shipments in constant 1988 dollars will result:

Projected Growth of World Microwave Equipment Shipments

| | Billions of Dollars | | |
|---|---|---|---|
| | 1988 | 1994 | 2000 |
| Constant 1988 dollars (no inflation) | 81 | 106 | 143 |

The U.S. is not penetrating the rest of the world market well. For example, U.S. exports in the category of "radio communication and detection equipment" (SIC Code 3662) were only $4.5B in 1988. Imports were higher at $5.0B, yielding a negative balance of trade and an export/import ratio of 0.9. Japan supplies 48% of all U.S. imports in this category, four times the contribution of any other country. Only 9% of U.S. exports in this category go to Japan.[21] In summary, the U.S. has a lot to gain by better penetration of the world market, and a lot to lose by increased penetration of its own market.

Current data on the performance of other countries in the world market for microwave equipment are difficult to obtain, but data for 1981 for telecommunications equipment indicate the strength of the chief competitors of the U.S.: Japan, Canada, and Europe. In that year, the U.S. still had a favorable balance of trade with an export/import ratio of 1.3. The table below shows that the competing nations achieved higher export/import ratios than the U.S. while maintaining high absolute levels of exports. Since 1981, the U.S. export/import ratio has declined to 0.9, as noted above.

1981 Telecommunications Equipment Trade Data[22]

| | Amount Exported, Ratio (re: 1.0 for U.S.) | Export/Import Ratio |
|---|---|---|
| U.S. | 1.0 | 1.3 |
| Japan | 1.4 | 19.8 |
| Canada | 2.2 | 2.1 |
| Europe | 4.6 | 3.8 |

Competing factors will affect the growth of the world market for microwave equipment. On the one hand, the demand for the services of microwave systems is rising, especially as new applications are identified. On the other hand,

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Editorial Seminar, sponsored by Hewlett-Packard (April 6, 1988).

[21] 1989 U.S. Industrial Outlook of the U.S. Department of Commerce, p. 27-2.

[22] "The Telecommunications Industry", U.S. Department of Commerce, International Trade Administration, p. 21 (April, 1983). Focuses on SIC Code 3661 only.

the cost of microwave equipment will fall if microwave integrated circuits and integrated antennas can be successfully developed. These cost reductions will be significant (factors of 100). As a result, the first nations to successfully commercialize microwave integrated circuits and antennas will gain a tremendous advantage in both the U.S. market and the international market for microwave products. The cost reductions, in turn, will inevitably open larger markets for microwave products.

The Japanese are among the nations that are pushing hard to develop microwave integrated circuits, driven almost exclusively by consumer applications. They are highly interested in direct broadcast satellites, mobile radio transmission systems, high-data-rate optical transmission systems, and signal processing for high-definition television (HDTV).[23] The Japanese have proven their ability to be competitive in telecommunications components. According to a recent NSF/DARPA assessment of Japan's telecommunications technology, "The components it [Japan] introduces into the market are increasingly the most advanced in technical characteristics and quality and the lowest in cost. Japan is verging on international market dominance at the components level."[24]

The Europeans are driving hard, too, with a special emphasis on telecommunications applications of microwave technology. They have become major standard setters in this field.

Impact of Optical Fibers

The emergence of optical fiber systems will affect the demand for microwave equipment but in a limited manner only, for two reasons. First, the demand for communications services is so high that all available means of transmitting data will be needed. Second, the emergence of optical fibers affects primarily one type of microwave service: point-to-point communications between areas of high population density. For other types of services, microwave technology will continue to dominate and expand: point-to-point communications services for areas of low population density; point-to-multipoint communication services in all areas; mobile communication services for land, sea, air, and space; sensing, including geological, agricultural, and weather sensing; radar; navigation; guidance; electronic warfare; industrial applications; and consumer applications. These microwave services require one or more of the characteristics that cable technology cannot provide:

| | |
|---|---|
| area coverage: | communications, sensing, radar, navigation, guidance, electronic warfare, consumer applications |

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[23] Far East Scientific Bulletin 11 (1) of U.S. Office of Naval Research, p. 112 (January-March, 1986).

[24] JTECH Panel Report on Telecommunications Technology in Japan - Final Report by the Japanese Technology Evaluation Program, sponsored by the National Science Foundation and the Defense Advanced Research Projects Agency, p. xi (May, 1986).

| | |
|---|---|
| movement: | communications with satellites or mobile vehicles including automobiles, aircraft, ships, and spacecraft; radar |
| flexibility: | communications, electronic warfare |
| microwave energy: | industrial, medical, and consumer applications |

"Flexibility" requires clarification. It takes several forms: (1) Microwave systems can be set up quickly without the need to resolve the difficult right-of-way problems that arise when laying cable. (2) Microwave installations are less sensitive to variations in the terrain than cable installations. (3) Satellite and terrestrial microwave systems can be reconfigured readily to serve different geographical areas and new users. (4) Satellite systems can serve vast areas of low population density just as easily as small areas of high population density. Because of this flexibility, microwave systems can serve in both permanent installations and temporary installations such as those used for emergencies.

While optical fiber technology does compete with microwave technology for some communications applications, the more salient relationship between the technologies is complementary or even symbiotic.[25] For example, microwave systems will provide "local area" delivery for signals carried across the country by optical fibers, particularly when mobile subscribers are involved. In fact, microwave and optoelectronic technologies will gradually merge as optoelectronic technology takes on functions in microwave systems and microwave technology takes on functions in optical fiber systems. Together, they will provide levels of performance that neither can achieve alone.

Technical Goals for Industry in Response to Marketplace Demands

To meet the demand for expanded and new microwave services and to compete internationally, U.S. industry must pursue three technical goals for microwave systems:

Goal #1: Improved performance
Goal #2: Reduced cost, size, and weight
Goal #3: Improved access to higher frequencies

To achieve Goal #1 of improved performance, industry must pursue higher information density, improved signal quality, and expanded versatility and flexibility:

> Higher information density can be achieved by increasing the information capacity of existing systems and by enabling a greater number of systems to operate without mutual interference in a given region. These advances are highly important because crowding is becoming increasingly serious as additional terrestrial systems come into use. In space, crowding will

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25 "The Evolving Symbiosis of Optical Fiber, Satellites", Washington Post, pp. H-1 and H-5 (August 21, 1988). Also, "Personal View: Systems Integration" by George Heiter, AT&T Bell Laboratories, Microwaves & RF, p. 126 (May, 1988).

become of special concern in 1990 when existing satellite capacity is expected to saturate.[26] Only limited space is available in the valuable geostationary orbit.[27] To enable satellites to operate without mutual interference, high performance antennas with low side lobes must be developed.[28] Also, higher frequencies must be used to provide additional spectral space. Finally, the information capacity of microwave frequencies already in use and of existing optical fiber systems must be increased by developing advanced microwave signal processing electronics.

Improved signal quality is needed to maintain low data error rates, especially as information capacity is increased. Improved signal quality is also needed to improve the sensitivity of microwave systems so that they can serve wider applications in communications, radar, and sensing. Such improvements will require improved fidelity in the microwave signal processing circuits for both digital and analog signals.

Expanded versatility and flexibility will also be required. They can be achieved by developing microwave systems that can operate on many different frequencies simultaneously and that can serve many different geographical areas simultaneously through electronically steered antennas.

To achieve Goal #2 of reduced size, weight, and cost of microwave components, miniature individual components and integrated components will be required for virtually all microwave frequencies. These components will be important for all applications but especially so for mobile, air, and space applications.

To achieve Goal #3 of improved access to the special capabilities and spectral space of the higher microwave frequencies, new electronic technologies capable of efficient performance will be needed. Both the 30-100 GHz range and the 100-1000 GHz range, where microwaves take on quasi-optical behavior, must be addressed.

NIST Measurement Support for Industry's Technical Goals

To support industry in pursuit of the above three technical goals, NIST must provide industry with a broad spectrum of advanced measurement capability. This measurement capability is needed to support research, development, manufacturing, voluntary industry standards for compatibility and other goals,

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[26] 1988 U.S. Industrial Outlook, p. 31-4.

[27] The geostationary orbit lies over the equator and is about 23,000 miles high. It is the only orbit which permits satellites to revolve about the earth in such as way that they remain positioned over the same point on the earth all of the time. This "stationary" position enables them to provide continuous service to the locations beneath them. To place more satellites in this orbit, the spacing between them must be reduced, increasing the problems of mutual interference with adjacent satellites.

[28] Antennas with low side lobes have minimal radiation off to the sides. Such antennas reduce mutual interference between adjacent satellites in orbit or between adjacent ground stations on earth.

specification, procurement, maintenance, acceptance of U.S. products in domestic and international markets, and international competitiveness broadly.

The urgency of this need has been stated in unqualified terms by U.S. industry:

> U.S. industry executives have joined together under the auspices of the Institute of Electrical and Electronics Engineers to form the Committee to Promote National Microwave Standards. The Committee members, which include company chief executive officers and chairmen of the board, have issued a report stressing the urgency of the measurement needs, decrying the weakening position of the U.S. compared to its competitors, spelling out the specific measurement problems, and urging resolution of them by NBS/NIST.[29]

> The National Conference of Standards Laboratories (NCSL), operating under the guidance of member executives of major U.S. high technology companies, surveyed 400 organizations (346 industry, 61 government, and 4 universities) to determine key measurement needs. NCSL found a serious shortfall in NBS/NIST measurement support for microwave technology with adverse effects on major sectors of U.S. industry. The report spelled out the measurement problems and urged resolution by NBS/NIST. It also noted the negative effects of inadequate measurement support on national goals, such as productivity improvement, quality improvement, and international competitiveness, among others.[30]

> Industry trade articles have highlighted the urgency of the need for expanded microwave measurement support from NBS/NIST for many years,[31] noting, for example:

> > "The NBS struggles under a woefully meager budget to research measurement technology and supply measurement services to support the measurements revolution of the '80s and the '90s. Truly an impossible task."[32]

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[29] The PNMS Report - Microwave Metrology in the U.S.A. by the Committee to Promote National Microwave Standards, an ad hoc committee sponsored by the IEEE Microwave Theory and Techniques Society (November, 1987).

[30] Report by the National Measurement Requirements Committee of the National Conference of Standards Laboratories, Sections 1 and 3 (Revision 2, April 1987). The findings of the original survey were published in 1983 and were updated in this latest 1987 revision.

[31] Jim Fitzpatrick, "NBS and Microwave Metrology -- Growing Concern within the Industry", Microwave System News, p. 43 (May, 1984). John L. Minck, "A (Modest) Proposal to Establish a National Bureau of Microwave Standardization", Microwave System News, pp. 67-71 (May, 1986). John Minck, "Some Significant Things That Have Happened to RF in the Last 10 Years", RF Design, pp. 29-34 (October, 1988).

[32] John Minck, "Some Significant Things That Have Happened to RF in the Last 10 Years", RF Design, pp. 29-34 (October, 1988).

The measurement capability that NIST must develop to address these concerns is outlined below in three projects. Each project corresponds to a key group of components that requires improved or new measurement support. Following the outline, the specific work that NIST must carry out for each project is described.

Projects of the Microwave Measurement Technology Initiative

1. Individual Components for 1-100 GHz
   1.1 Electronic Devices
   1.2 Antennas

2. Integrated Components for 1-100 GHz
   2.1 Integrated Electronic Circuits
   2.2 Integrated Antennas

3. Integrated Components for 100-1000 GHz
   3.1 Integrated Electronic Circuits
   3.2 Integrated Antennas

The order of the three projects above indicates the order in which NIST will fund measurement development if initiative funding becomes available. Since the most immediate needs are in the 1-100 GHz range, that range is addressed before the 100-1000 GHz range.

1. Individual Components for 1-100 GHz

The new measurement methods needed for individual components must embody major advances over those currently available. These advances are summarized in the list below and are explained more fully in the paragraph that follows:

Higher accuracy: typically ten times greater

Susceptibility to automation: manual measurement methods too slow for sophisticated new microwave systems

Continuous frequency coverage: not just selected frequencies

Broader interface compatibility: new microwave interfaces for miniature components and new optoelectronic devices

The new measurement methods must be typically ten times more accurate to support emerging high performance systems. They must be susceptible to automation since modern systems are so complex that they cannot be efficiently characterized with today's manual measurement methods. The new measurement methods must operate over broad, continuous frequency ranges to support new systems with greater frequency flexibility; in the past, measurements at key fixed frequencies sufficed. The new methods must support a broader range of interfaces for two reasons: new miniature microwave components, with new types of interfaces, are being introduced to cut the size, cost, and weight of microwave systems; and new optoelectronic devices will be interfaced with microwave devices. For example, optical fibers will likely replace metal waveguides in key roles in satellites and antennas. The fibers are

lightweight, low cost, and flexible and do not interfere with microwave beams. They may serve as signal interconnections within satellites or as controlling lines within powerful phased array antennas, among other applications.[33]

The individual components that require improved measurement support may be divided into two groups: (1) electronic devices that generate, process, and transport microwaves without radiating them, such as signal sources, amplifiers, detectors, waveguides, coaxial cable, and connectors; and (2) antennas that transmit and receive the microwaves. The measurement needs of these two classes of components are described below.

1.1 Electronic devices

NIST must develop new measurement methods for determining critical microwave quantities in individual electronic devices. The most critical measurement needs correspond to the two functions that a microwave system must perform to convey information from one location to another: (1) transfer microwave power efficiently, and (2) preserve signal fidelity while doing so.

Power transfer measurements

| | |
|---|---|
| power | Determines power levels throughout a microwave system. |
| impedance | Enables components to be interconnected compatibly, with minimum power loss. |
| attenuation | Determines power loss within a component. |

Signal fidelity measurements

| | |
|---|---|
| waveshape | Enables evaluation of signal quality throughout a system and determination of performance of signal sources, amplifiers, modulators, detectors, and electronic switching devices. |
| noise | Enables minimizing electronic noise to optimize information throughput and to reduce errors in transferring data in a microwave system. |

Noise measurements serve as an example of the problems currently faced by industry. Noise is the single most important characteristic of microwave amplifiers and amplifying components (transistors); premiums are charged and

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[33] Phased array antennas contain many radiating elements. By controlling the strength and phase of the signal emitted by each element, the array can be made to produce diverse and well controlled radiation patterns to serve special needs. For example, phased array antennas can be designed to illuminate receiving areas of diverse shapes, or to reduce of unwanted side lobes (radiation off to the side of the antenna) that could interfere with adjacent microwave systems. The "phase" of an element determines the moment at which the alternating microwave signal fed to it goes through its maximum value, relative to the corresponding moments for the signals fed to the other elements.

paid for good noise performance. Noise performance affects the sensitivity and information capacity of systems. Yet present noise measurement capability is not adequate to characterize the noise performance currently being achieved in modern products, so manufacturers and buyers cope constantly with inadequate tools for product development, specification, and evaluation. As a result, manufacturers have repeatedly sought NIST assistance in resolving this problem. NIST must develop methods for measuring noise that are far better than those currently available and that are suitable for adoption as standard methods industry wide.

NIST must also develop measurement methods for determining the microwave properties of materials. The quantities for which measurement methods and data are required are these:

Materials measurements

| | |
|---|---|
| permittivity | Determines the electrical properties of the materials. |
| permeability | Determines the magnetic properties of the materials. |
| uniformity | Determines the degree of uniformity (homogeneity) of materials properties throughout the material. |
| anisotropy | Determines the degree of uniformity of materials properties as a function of angular orientation. |

The performance of microwave components is very sensitive to the microwave properties of the materials of which they are made. That sensitivity is particularly important in the design of the "substrates" (similar to the circuit boards of conventional electronics) that provide the waveguide channels that interconnect individual microwave electronic components. Unfortunately, most existing data on the microwave properties of materials are based on measurements made many years ago on conventional materials at frequencies below 10 GHz. Few data exist for frequencies above 10 GHz, and practically no data exist for newer materials.[34]

1.2 Antennas

For antennas, NIST must develop measurement methods that can provide greater accuracy, improved susceptibility to automation, broader frequency coverage, and better control of the radiation pattern of antennas. Such measurement capability will enable antennas to deliver stronger signals to receiving stations, to work in close proximity to other antennas without mutual interference, and to serve applications requiring greater sensitivity and versatility. The phased array antenna is a key example of the type of powerful modern antenna requiring improved measurement support.

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[34]NIST surveyed industry's measurement requirements for microwave materials and described the urgent needs in its "Summary Report on Measurements and Standards Requirements for Materials Used in Electromagnetic Applications: Results of a Limited Survey" (February, 1985). Everything from substrates, to protective antenna covers (radomes), to microwave integrated circuits is affected. For example, better materials measurements are essential to the success of the automated design and manufacturing processes that produce microwave integrated circuits; these circuits, in turn, can cut the cost of microwave electronics by factors up to 100.

The measurements required fall into two classes: (1) antenna measurements, and (2) materials measurements. The initiative must address antenna measurements for 26-100 GHz[35] and materials measurements for 1-100 GHz.

Antenna measurements

| | |
|---|---|
| gain | Determines how successfully an antenna can focus its power in the forward direction, toward the intended receiving antenna. |
| pattern | Determines focusing performance of an antenna in all directions, essential for illuminating the desired receiving area and for reducing stray radiation that can interfere with adjacent systems. |
| strength | Determines strength of the microwave beam from a transmitting system. |
| polarization | Determines a special property of an antenna that allows it to send two non-interfering signals on the same frequency to double its information handling capacity. |
| bore sight | Determines how closely an antenna radiates in the expected direction. |
| natural signal source characterization | Enables use of the sun, moon, key planets, and stars as natural signal source standards for evaluating and maintaining the performance of earth terminals and satellite microwave systems while in service. |

NIST will also develop measurements for the properties of microwave materials used with antennas, with a special emphasis on materials used for protective covers (radomes) for the antennas. The microwave properties of these materials are not well understood, especially at frequencies above 10 GHz; yet those properties significantly affect the performance of antennas. The key parameters that must be measured for antenna materials are these:

Materials measurements

| | |
|---|---|
| permittivity | |
| permeability | |
| uniformity | |
| anisotropy | |
| transmissivity | Determines how well the material passes microwave power. |
| reflectivity | Determines the amount of microwave power reflected by the material. |

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[35]Development of measurements for antennas (non-integrated) below 26 GHz is supported by existing NIST resources.

## 2. Integrated Components for 1-100 GHz

Increasingly, microwave systems will be built in integrated form to reduce size, weight, and cost. Integration will take two principal forms:

Integrated electronic circuits: integration of microwave electronic devices, like signal sources and waveguides, onto a common substrate along with associated optoelectronic devices

Integrated antennas: integration of the elements of an antenna onto a common substrate along with associated electronic and optoelectronic devices

Integration poses difficult measurement challenges for several reasons:

Minimal measurement ports: Input and output ports of electronic devices within integrated circuits are not readily accessible. In individual components those input and output ports provided convenient locations for attaching measurement devices.

Measurement probe sensitivity: Circuit elements are closer to each other, so measurement probes are more likely to disturb the circuits that they measure.

Materials sensitivity: The performance of circuits made in integrated form is even more sensitive to materials properties than the performance of circuits made from individual components.

Multiple technologies and interfaces: The incorporation of optoelectronic technology in integrated microwave circuits and antennas leads to an especially complex mix of technologies and interfaces.

These differences necessitate new definitions for measured quantities, new measurement methods, and new physical standards to support those measurement methods.

### 2.1 Integrated electronic circuits

The integration of microwave electronic devices is pursued for reasons similar to those that motivated the integration of conventional semiconductor devices. However, the structures required, the materials employed, and the types of devices used all differ. Also, microwave integrated circuits operate at 1000 times the frequency of most semiconductor integrated circuits (GHz versus MHz), making the performance of the microwave circuits much more difficult to measure. In particular, they are much more sensitive to the presence of measurement probes.

To date, the lack of measurement methods suitable for microwave integrated circuits has hampered the design of integrated circuits and the development of fabrication processes for making them. Measurement problems in microwave integrated circuits are so critical that major manufacturers estimate that 80-90% of the cost of the resulting devices is associated with testing.

There are four classes of measurements that must be developed to support microwave integrated circuits. They can best be distinguished by the locations at which the measurements are made:

(1) Inside devices: measurements internal to the electronic devices within the integrated circuits, to support their design and fabrication

(2) Input/output ports of devices: measurements at the input and output ports of the electronic devices within integrated circuits, to determine the overall performance of the devices and to establish how well they transfer microwave signals to interconnecting waveguide channels

(3) Inside waveguide channels: measurements to determine the performance of the interconnecting waveguide channels themselves

(4) Inside materials: measurements to characterize the microwave properties of the substrates and other starting materials used to make both the electronic devices and the waveguide channels within the integrated circuits.

Measurement development for category (1) will be adequately supported by NIST's Advanced Semiconductor Initiative if all parts of that initiative are funded. Measurements for categories (2), (3), and (4) will require support from this Microwave Measurement Technology Initiative.

For categories (2) and (3), NIST must develop new measurements for the following quantities:

Power transfer measurements

power
impedance
attenuation

Signal fidelity measurements

waveshape
noise

These are the same quantities applicable to individual electronic components, but the measurement methods required are entirely different. Because of the small scale of integrated circuits and the proximity of all of their components, special measurement methods will be required to access the internal workings of the integrated circuits and to prevent interference with their operation during the measurement process. If some interference occurs, it must be minimized. Corrections for any remaining interference must be made based on theoretical calculations. Special contacting electrical measurement techniques and non-contacting optical measurement techniques must be developed to accomplish these aims. Also, special test structures must be developed that can be built right into commercial integrated circuits to facilitate measurement.

For category (4), NIST must develop measurement methods and supporting

physical standards for the following propetties of the materials used in microwave integrated circuits:

Materials measurements

permittivity
permeability
uniformity
anisotropy
transmissivity
reflectivity

Lack of data on the microwave properties of materials is severely impairing the design and manufacture of integrated circuits. Such data are essential for systems used in automated manufacturing and computer-aided design since these systems depend on materials of known and uniform properties. As noted above, most existing data on the microwave properties of materials are based on measurements made many years ago on conventional materials at frequencies below 10 GHz. Few data exist for frequencies above 10 GHz, and practically no data exist for newer materials.

The materials properties of interest must be measured as a function of temperature and humidity to simulate true conditions when in use. They must be measured as a function of composition to support design and manufacturing processes. They must be measured as a function of frequency to support wideband (frequency flexible) applications.

2.2 Integrated antennas

Integrated antennas are one of the most promising of emerging microwave technologies. They are panels, either flat or curved, which contain embedded metallic radiating elements that look much like the wiring patterns in an integrated circuit. Integrated antennas may contain thousands of elements, especially when configured as phased array antennas.[36] Integrated antennas can be very large (many meters in size) or very small (a few centimeters in diameter, fabricated directly on the surface of a single semiconductor wafer). Integrated antennas will contain electronic devices built right into them. These devices will serve as small transmitters and receivers. Each transmitter or receiver may be associated with individual radiating elements or with groups of elements within the antenna. The elements in an integrated

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[36]The integrated phased array will be a powerful type of antenna. Its radiation pattern and direction of radiation will be electronically controlled, without physical motion of the antenna. The control is accomplished by adjusting the strength and phase of the signal radiated by each element within the antenna. In some configurations, each element of the antenna will have its own transmitter and receiver. In other configurations, each element will have its own phase shifter but will share its receiver or transmitter with several other elements. In still other configurations, groups of elements will have a single phase shifter; and many groups, or even all groups, will share a common transmitter or receiver.

antenna may be controlled by optoelectronic devices.[37] The elements may contain built-in signal processing circuits.[38] Some new antenna designs are so complicated that they cannot be economically constructed without integration.[39]

Integrated antennas offer several advantages over conventional antennas:

Reduced size, cost, and weight: Embedding the elements in an insulating substrate reduces the structural complexity of an antenna considerably.

Adaptable shapes: Integrated antennas can be shaped to conform to the skin of a vehicle, such as an airplane, satellite, or spacecraft, and thus can meet the special aerodynamic and structural requirements of those vehicles. They can also be shaped to conform to the surfaces of buildings for aesthetic or practical reasons.

Sophisticated designs: Integrated antennas can be implemented as phased arrays, the most versatile of emerging antenna types. Phased arrays can transmit in many directions without being physically moved (electronic steering). Both the direction of transmission and the shape of the radiation pattern can be changed virtually instantly. This capability enables a single satellite with such an antenna to serve many different geographical regions on a time-shared basis by sending its signal to one location after another in rapid succession.

Integrated antennas can be driven by multiple small low power transmitters, built right into them. They do not require the traditional single high power transmitter. The use of multiple transmitters eliminates the need for a complex network of microwave waveguides within the antenna to carry microwave power to the antenna elements from a central transmitter. The result is a considerable reduction in weight. Also, because the transmitters for the individual elements are low power, they can employ low cost semiconductor signal sources, rather than the expensive and often short-lived microwave tubes that are required by high power central transmitters. Integrated

---

[37]Optical waveguides embedded in a phased array integrated antenna may be used to control the relative strengths and phases of the signals transmitted by the individual elements of the antenna. Relative to metallic waveguides, which would otherwise be used for such control, the optical waveguides are lighter and will not interfere as much with the radiation pattern of the antenna.

[38]For example, the information received by each element of an integrated receiving antenna may be converted to digital form by its own semiconductor electronics, located right at the antenna element. The resulting digital data from each antenna element can then be brought out of the antenna on light beams carried by optical waveguides. This approach results in a much lighter antenna than possible when microwave signals themselves must be brought out through multiple metallic waveguides.

[39]The individual faces of an active array may contain as many as 5000 active transmit/receive devices and thus may not be practical to implement in any form other than an integrated form.

antennas may be controlled with optical signals fed through optical waveguides. Optical waveguides are desirable because they are non-interfering; thousands of such signals will be required to control a complex integrated antenna.

To support integrated antennas, NIST will develop measurements for overall antenna performance and for the performance and interaction of individual antenna elements within the integrated antenna. The principal quantities that must be measured are these:

Overall antenna measurements

| | |
|---|---|
| gain | |
| pattern | |
| polarization | |
| bore sight | |
| noise | Determines the noise contributed by the integrated antenna which now contains the transmission and reception electronics and must be evaluated as a whole. |

Antenna element measurements

| | |
|---|---|
| diagnostics | Determines which elements of the antenna are not working correctly. |
| coupling | Determines the effects of the coupling between closely spaced elements on antenna performance. |
| phase | Determines how the signals from the individual elements track in relation to each other. |
| strength | Determines how well the strengths of the signals from the individual elements track with each other. |

The new measurement approaches required will be especially challenging for several reasons:

No single input/output port: Integrated antennas do not have a single point of microwave power input or output which can provide a reference for measurements. New definitions for quantities such as gain and noise will be necessary, along with new measurement approaches.

Different transmit/receive performance: Integrated antennas will not perform exactly the same way in transmission and in reception, as conventional antennas do; so separate measurements must be made for each of these modes. The differences arise from the fact that different built-in electronics will be activated for reception versus transmission. Also, in some cases, different r 'ating elements within the antenna will be used for each mode.

Large size: Integrated antennas will often be physically large. They will also often be "electrically large". That is, they will be large relative to the wavelength (the distance from one ripple to another in a traveling microwave beam). Because of these "large" sizes, NIST will

need to develop new measurement methods for pattern. These new methods must enable present-day antenna measurement ranges to cope with antennas that are far too complex for use of traditional measurement approaches. So called quasi-far-field measurement techniques will be required.

Element interactions: Integrated antennas are composed of many elements, so the interactions among these elements will greatly affect performance and will require a variety of measurements sensitive to the relationships among them.

NIST must also develop measurements for characterizing the microwave properties of the special materials used in making integrated antennas. The quantities that must be measured are these:

Materials measurements

permittivity
permeability
uniformity
anisotropy
transmissivity
reflectivity

As with materials for integrated circuits, these quantities must be measured as a function of temperature and humidity to simulate the environment in which they will be used. They must be must be measured as a function of composition to support design and manufacturing processes. They must be measured as a function of frequency to support wideband applications.

3. Integrated Components for 100-1000 GHz

New measurement capability must be developed for the 100-1000 GHz region. This capability is needed to support the efforts of U.S. industry to develop equipment that will take advantage of the frequency space and special properties of the higher frequencies. Particularly attractive are the prospects for smaller antennas, higher resolution for local radar, greater versatility for local communications systems, and ultrafast speeds for signal processing.

Most of the needed work will focus on integrated components, so they are the focus of the subsections that follow. However, some measurement development for individual components will also be needed.

3.1 Integrated Electronic Circuits

The key parameters that must be measured are the same as those specified for the 1-100 GHz range in section 2.1, but different measurement methods will be required. The differences are caused by -

Quasi-optical behavior - The frequencies in the 100-1000 GHz range, particularly at the high end, take on the behavior of light, giving rise to new materials problems, new requirements for component designs, and higher levels interface complexity.

Smaller geometries - The characteristic sizes of circuit elements will be smaller at these frequencies.

Higher sensitivity to measurement probes - The sensitivity of integrated circuits to the presence of measurement probes will be greater at these frequencies.

Higher sensitivity to materials properties - The sensitivity of integrated circuits to materials properties will be greater at these frequencies.

In this 100-1000 GHz domain of frequency, development of non-contacting optical methods, rather than contacting electrical methods, for measuring microwave parameters within integrated circuits will be especially important to prevent disturbing the circuits being measured.

The full spectrum of materials properties cited for the range of 1-100 GHz in section 2.1 must be addressed for this new frequency range of 100-1000 GHz where the properties will differ considerably.

Measurements supportive of microwave signal processing electronics will be especially important to realize the promise that they offer for extraordinary processing speeds.

3.2 Integrated Antennas

Measurement development for antennas will focus initially on the domain of 100-300 GHz and later on the domain of 300-1000 GHz. As in category 3.1 above, special measurement methods will be needed to cope with quasi-optical behavior, smaller geometries, and higher sensitivity to measurement probes and to materials properties. In addition, measurements for coupling among antenna elements and other circuit elements will prove very important and challenging at these frequencies.

Development of measurement support for the range of 100-1000 GHz will assure that U.S. industry has both the measurement methods and the materials data that it needs to accelerate its research and development efforts toward the next generation of high frequency microwave products.

SUPERCONDUCTOR PROGRAM SUMMARY
FY 1988-89

Introduction

The purpose of the NIST Superconductor Program is to provide measurement methods and materials data needed by U.S. organizations for developing practical superconductor products. NIST achieves high leverage by providing measurement capability that accelerates the superconductor programs conducted by industry, universities, Government agencies, and national laboratories. In particular, the NIST program provides measurement support for: (1) relating materials characteristics to underlying physics; (2) characterizing new materials in basic form; and (3) developing and controlling processes for converting basic materials to practical materials. NIST also applies superconductor technology to advanced measurement devices. NIST addresses high and low temperature superconductors in both bulk and thin-film forms. In the future, NIST plans to develop measurement capability to support marketplace exchange for high temperature superconductor products. NIST already provides this support for low temperature superconductor products.

The NIST Superconductor Program has the levels of directly appropriated resources shown below. The $2M increase in FY 1989 for high temperature superconductors applies for that year only.

| | Thousands of Dollars | |
|---|---|---|
| | FY 1988 | FY 1989 |
| Low Temperature Superconductors | 570 | 470 |
| High Temperature Superconductors | 2800 | 4800 |

The low temperature program has been a formal activity since 1969. The high temperature program was started on a pilot level in 1987 and constitutes the work of the Superconductivity Research Center for Electronic Applications, as called for in the President's Superconductivity Initiative of July 28, 1987. Since 1987, NIST has prepared 100 publications describing the results of its work on high and low temperature superconductors. NIST works closely with collaborators in industry, universities, national laboratories, and Government agencies to assure that it is providing the measurement methods and data that their programs need. In fact, 34% of NIST's recent superconductivity publications have been co-authored with those organizations.

In its work, NIST focuses on measurement methods and data that are needed broadly and that require NIST's special measurement skills or its special facilities, such as its synchrotron, research reactor, or integrated circuit facility. NIST's reputation for impartiality and competence in measurement science is essential in achieving broad acceptance of NIST-developed measurement capability. Such acceptance strengthens the national superconductivity effort by accelerating research, by improving the quality of published data, and by enabling more meaningful comparison of findings among U.S. organizations.

Plans

The NIST program can be described in three projects that are focused on the types of measurement support that NIST is providing to U.S. organizations.



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Project 1: Measurement Support for Relating Materials Characteristics to Underlying Physics

Project 2: Measurement Support for Characterizing New Materials in Basic Form

Project 3: Measurement Support for Developing and Controlling Processes for Converting Basic Materials to Practical Materials

A brief description of each project follows.

Project 1: Measurement Support for Relating Materials Characteristics to Underlying Physics

Project Focus:

NIST is providing measurement methods and data that advance the understanding of the underlying physics of superconducting materials. This information is needed to support the national effort to find new superconducting materials and to understand and optimize the performance of those already discovered. Representative of the key measurement methods that NIST is using are photoemission, x-ray fluorescence, elastic constant, electron tunneling, and neutron scattering methods. These measurement methods provide data on electron energy levels, energy gap, density of states, phase transformations, phonon behavior, electron-phonon interactions, atomic structure and substitutions, and magnetic behavior.

NIST itself is not pursuing the discovery of new superconducting materials; rather, NIST is providing the measurement methods and data that accelerate the progress of other U.S. organizations engaged in that pursuit.

Representative FY 1988 Accomplishments:

NIST has applied key measurement techniques to determine fundamental data on the copper valence states, key interatomic bonds, elastic and phonon behavior, and the energy gap in the yttrium-based high temperature superconductor. NIST has used neutron measurement techniques to develop data on the effects of non-magnetic atomic substitutions in the yttrium-based superconductor and to identify the significance of copper-oxygen planes versus copper-oxygen chains to the mechanisms of superconductivity.

Representative FY 1989 Plans:

NIST will use neutron measurement techniques to develop data on the effects of magnetic atomic substitutions in the yttrium-based high temperature superconductors. NIST will expand development of data on electronic structure and other properties of the new bismuth-based high temperature superconductor.

Project 2: Measurement Support for Characterizing New Materials in Basic Form

Project Focus:

NIST is developing measurement methods and verified data that industry needs to characterize the basic materials from which superconducting products will be made. Key among these undertakings is the development of phase diagrams, x-ray diffraction data, atomic structural data, and measurement methods and data for compositional uniformity.

Phase diagrams identify stable phases of superconducting materials as a function of composition and temperature. Phase diagrams are fundamental sources of data needed by industry to design processes for making superconducting materials. X-ray diffraction patterns enable quick identification of the compounds formed. Atomic structural data are needed to characterize the sensitivity of the superconducting properties of the new materials to subtle changes in atomic positions and occupancy. Measurement methods for compositional uniformity are needed to improve the homogeneity of superconducting materials. To meet these needs, NIST is expanding its special capabilities for neutron diffraction and compositional mapping.

Measurement methods and data for characterizing new materials in basic form are the necessary first step toward the development of measurement support for process control, described in the next project. New data will be developed for each emerging family of high temperature superconductors with promise for practical products.

Representative FY 1988 Accomplishments:

NIST has developed the phase diagram and x-ray diffraction data for the yttrium-barium-copper-oxide superconductor, compositional mapping capability with micrometer resolution for the metallic constituents of the new superconductors, atomic structural information with emphasis on oxygen-site occupancy using neutron diffraction, and atomic building-block models with predictive capability for high temperature superconductors. NIST has also completed the conceptual design for a new neutron diffractometer with improved capability for determining atomic structure.

Representative FY 1989 Plans:

NIST will develop the phase diagram for the bismuth-calcium-strontium-copper-oxide superconductor. NIST will also develop compositional mapping measurements with submicrometer (nanometer) resolution for principal constituents. NIST will explore a broadened spectrum of measurement techniques for the elemental and chemical makeup of high temperature superconductors, with a special focus on oxygen which is very difficult to measure. NIST will implement the first of several key improvements to its neutron diffraction capability for measurements of atomic structure and other relevant materials parameters.

Project 3: Measurement Support for Developing and Controlling Processes for Converting Basic Materials to Practical Materials

Project Focus:

To develop fabrication processes, industry must have fundamental measurement methods and data for relating processing conditions to desired properties in superconducting materials suitable for products. NIST is developing this measurement capability to aid industry in developing processes and in determining the quality and performance of practical materials produced by those processes. Both bulk materials (for wires) and thin films (for integrated circuits) are being addressed.

Bulk materials

NIST is developing and applying a variety of measurement techniques for determining the variation of crystal structure and chemical composition with processing conditions. NIST is determining the relationship between processing conditions and both mechanical properties (such as structural strength) and key superconducting properties, such as critical temperature and critical current. Included will be the determination of the relationship between processing variables and flux pinning, which affects critical current and ac losses. Measurement methods are being developed and used to provide generic data on variation of critical current with magnetic field, stress, and temperature.[1] Key measurement methods are being documented for broad use as national measurement standards. This effort and others within the program are responsive to the requirement "to develop and coordinate common standards" as stated in the President's Superconductivity Initiative.

Thin films

NIST is providing special measurement capability and data to support the exploitation of the high temperature superconductors in integrated circuits for electronic applications. Using the best available fabrication technology, NIST is establishing its fabrication capability for preparing all elements of superconducting integrated circuits, including thin films, insulating cross-overs, and Josephson junctions. NIST is addressing key problems that affect the characterization of films, such as determining contact quality between normal metal films and superconducting films. NIST will aid in the transfer of data related to thin-film fabrication technology to industry to support industrial development of commercial thin-film fabrication processes. NIST is also exploiting its fabrication capability to

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[1]Outside funding (principally from DOE's Fusion Energy Program and High Energy Physics Program) contributes significantly to related work, particularly for low temperature superconductors. That funding supports development of measurement methods for critical currents above 600 amperes and complements earlier work on measurement standards for lower current levels. The outside funding also supports development of measurement methods for ac losses in multifilamentary superconductors, determination of coupling effects and stress-related critical current degradation within multifilamentary superconductors, determination of effects of low-level copper impurities on the superconducting energy gap, and other activities.

provide new superconducting devices with a special focus on national electronic measurement standards and other measurement devices. NIST earlier developed the present U.S. national standard for voltage, based on an integrated circuit array of Josephson junctions, made from the low temperature superconductors. NIST also developed the first high temperature superconducting quantum interference device (SQUID) that was fully characterized as a measurement instrument. This device measures magnetic fields with high sensitivity. Other devices that measure magnetic fields will also be developed, as called for in the President's Superconductivity Initiative.

Representative FY 1988 Accomplishments:

For bulk materials, NIST has developed new standard measurement methods for critical current at zero applied magnetic field in high temperature superconductors; to accomplish this, NIST reduced contact resistance by eight orders of magnitude to enable more accurate and reproducible measurements, especially at high current levels. NIST has shown that the superconducting properties of the high temperature superconductors are highly sensitive to processing conditions and impurities. In particular, NIST has established the relationship between transition temperature and oxygen annealing, has demonstrated that critical current can be increased with impurity reduction and with chemical preparation techniques for starting powders, and has determined the trade off between mass density and critical current in sintered materials.

For thin films, NIST has implemented its first fabrication capability for high temperature superconductors and has produced films with good superconducting properties. NIST has created single-layer patterns in those films with structures representative of those required for interconnections and ultimately for active devices. These are the first steps toward application of the high temperature superconductors to measurement problems. For low temperature superconductors, NIST has implemented a new version of the one-volt national standard using all-niobium technology. This technology provides high stability in the integrated-circuit array of Josephson junctions used in the standard. NIST has also implemented the first version of a ten-volt national standard with lead/niobium technology.[2]

Representative FY 1989 Plans:

For bulk materials, NIST will develop standard measurement methods for critical current versus applied magnetic field and for critical magnetic field in high temperature superconductors. These measurement methods will provide greater accuracy and reproducibility in evaluating materials produced by promising fabrication processes. NIST will develop and apply measurement methods for determining the correlation of processing variables and microstructure with mechanical, electrical, magnetic, and structural properties. Special emphasis will be given to structural defects and to grain

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[2]Outside funding (principally from DOD) contributes significantly to the application of low temperature superconductors to new measurement devices for voltage, millimeter-wave power, millimeter-wave signals for radio astronomy, and high speed waveforms via superconducting analog-to-digital converters.

alignment to overcome anisotropy problems. NIST will also continue to examine promising chemical preparation routes. Much of this work will focus on the yttrium-based superconductor, but the bismuth-based superconductor will be increasingly addressed.

For thin films, NIST will implement more powerful fabrication processes that provide greater control. This effort is the next step toward development of NIST's capability for making high temperature superconducting integrated circuits with active elements, with an emphasis on measurement applications. NIST will focus on low-loss circuit interconnections, on compatibility of multi-layers with each other and with substrates, and on measurements and data required to realize working Josephson junctions. For low temperature superconductors, NIST will take further steps toward implementation of all-niobium technology and will move from an initial to an advanced form of the new 10-volt national standard. NIST will also explore the potential of new superconducting effects for national standards.

ADVANCED MAGNETICS METROLOGY
Future Initiative
Project Plan

The science and practice of magnetics has stagnated in the United States in spite of the existence of major industrial segments such as magnetic recording (U.S. market for magnetic recording devices of $40 billion in 1987, estimated to be growing at some 20% per year). "Magnetic materials are an integral part of our modern industrial society, often rivaling semiconductors for breakthroughs in high-technology capabilities. They play a key role in power distribution, they permit the interconversion of electrical and mechanical energy, they underlie microwave communication, and they provide both the transducers and the active storage material for data storage in computer-based information systems." These sentences, taken from Directions in Engineering Research -- An Assessment of Opportunities and Needs, Report of the Engineering Research Board of the National Research Council, document the importance of magnetic technology, impacting a large fraction of the U.S. electronic market (U.S. firms shipped $223 billion in 1987) and individual industrial sectors ranging from motors and generators (U.S. firms shipped $7 billion in 1986) to industrial controls (U.S. firms shipped about $5 billion in 1986). [1-2]

Yet this prestigious Board found that "Despite the many practical uses for the materials, and despite their critical importance to the nation's industry and defense, it has become increasingly clear in recent years that the role of the United States in the science of magnetic phenomena, in magnetic materials, and in magnetic technology has been declining....Since the mid 1970s, American manufacturers have looked increasingly to foreign sources for newer, better, and cheaper magnetic materials and devices. Nations such as Japan have invested far more than the United States has in the R&D needed to advance the performance of magnetic materials."

Robert M. White, Chief Technical Officer and Vice President of Research and Engineering of Control Data, echoes this view in a 1987 commentary in Physics Today: "In fact, the whole field of magnetics has largely been ignored by the U.S. science community." "In 1985 the National Academy of Sciences sponsored a study of magnetic materials in the United States through the National Materials Advisory Board. The results of the study showed that although magnetic technology is critical to our economic and strategic well-being, we are rapidly losing our ability to compete."[3]

White goes on to report that "Recent workshops at Purdue University (sponsored by the Office of Naval Research) and in San Diego (sponsored by DARPA) reached

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[1]Directions in Engineering Research -- An Assessment of Opportunities and Needs, Report of the Engineering Research Board, Commission on Engineering and Technical Systems, National Research Council, p. 250; National Academy Press (1987).

[2]1989 U.S. Industrial Outlook, Chapter 25 Electrical Equipment, pp. 25-1 through 25-4; U.S. Department of Commerce (January 1989).

[3]Physics Today, Vol. 40, No. 11, p. 89 (November 1987).

the same conclusion." And the head of a magnetics group in the U.S. Naval Research Laboratory notes, "The precarious status of the magnetic recording industry here in the United States vs. Japan is now widely recognized and the amount of time still available to ensure our technological competitiveness is extremely short."[4]
The evidence is in: the state of U.S. magnetic technology is parlous, and the U.S. magnetics industry is under serious market threat from abroad. Various programs are being proposed to address the situation. Inevitably, comparisons are made with the semiconductor industry, and at least one proposal is modeled on the creation of SEMATECH.[5]

For these proposals to succeed, they (like SEMATECH) will need to consider carefully the measurements needed. NIST is already being called upon to provide infrastructure support for magnetics as it has for semiconductors and many other areas -- providing reference data and materials, developing and disseminating test methods needed by industry for marketplace measurements, contributing to voluntary standards development, providing calibration services for parameters required by industry, and serving as the measurement court of high appeal.[6] It should be noted that, with industry support and collaboration, centers to develop basic magnetic technology have been established at Carnegie Mellon University (Magnetics Technology Center); at the University of California at San Diego (Center for Magnetic Recording Research); and at the University of Minnesota (Center for Magnetics and Information Technologies). These centers primarily are concerned with research leading to commercial implementation and as a consequence do not conduct substantive metrology development. They also are not in position to provide the national reference measurements and services needed by industry and for commerce.

This draft Advanced Magnetics Metrology budget initiative describes that component of the NIST response falling within the technical competence of the Center for Electronics and Electrical Engineering.[7] It addresses current industry needs, reflecting priorities identified by industry in the Survey, through numerous contacts at meetings, in visits by NIST staff to industry, and in visits by industry to NIST.

High-Density Information Storage

The U.S. magnetic recording industry has serious measurement needs with respect to present technology and products and will depend on measurements

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[4]Private communication.

[5]Institute of Electrical and Electronics Engineers Magnetics Society Newsletter, Vol 24, No. 5, p. 3, 5 (May 1988).

[6]NBSIR 84-3018, F.R. Fickett, Magnetic Measurements, Calibrations, and Standards: Report on a Survey (October 1984).

[7]For indication of scope of accomplishments, see NBSIR 88-3097, Metrology for Electromagnetic Technology: A Bibliography of NBS Publications, section on "Superconductor and Magnetic Measurement," pp. 36 through 55 (August 1988).

even more in the future with increasing emphasis on quality control and advanced recording systems. For example, analysis of a coercivity round-robin exercise conducted by NIST with volunteers from industry and university research laboratories shows such a broad spread in the results that systematic differences are masked between the two principal instruments used (vibrating-sample magnetometer and B-H looper). NIST measurements show that the tape specimens used in this study are not the source of these large variations. Since coercivity is the single most important characteristic for specifying the performance of magnetic recording media, the situation is serious. One small company has already failed in part at least because of an inability to agree on coercivity measurements with its customers.

The development of new recording technologies (vertical, ceramic, and thin film media; magneto-optical recording) and the increase in bit density of the conventional technologies require either an improvement in existing measurements or new methods that are more accurate and dependable. Not only is the recording medium itself involved, but also the read/write heads and other auxiliary equipment.

Coercivity

In response, NIST will investigate measurement problems in magnetic recording, beginning with a study to identify the physical causes of the wide variation evidenced in coercivity measurements. This study will provide an understanding of the interaction of a given instrument type with the system under measurement and identify those measurement conditions that need to be controlled. Nist will also develop the artifact standards (Standard Reference Materials), calibration services, or both required to support industrial use of the vibrating-sample magnetometer (VSM) and the B-H looper. NIST also will carry out round-robin evaluations of test methods for media having high coercivities, such as new videotapes.

Magnetization and Demagnetization Parameters

An understanding of time-dependence effects in the magnetization cycle of magnetic media is another area that has been identified as being of great importance to industry. NIST will develop methods for determining and characterizing these effects, working with industry to institutionalize these methods in voluntary standards developed under the aegis of the American Society for Testing and Materials, the American National Standards Institute, the Institute of Electrical and Electronics Engineers, and other appropriate professional and technical societies. More specifically, NIST will study these effects using a new method based on toroidal specimens; NIST will also investigate Barkhausen noise in thin-film heads used for recording on high-coercivity media.

With respect to thin-film media, NIST will develop methods for accurate measurement of magnetization (moment per unit volume) which will account for the uncertain demagnetization factor and the regional demagnetization fields as well as the problems resulting from the multilayer nature of the specimens. To support future technologies, NIST will expand this work to cover magneto-optic systems and other high-density media.

Hard Disk Measurements

Hard disks pose special measurement problems to industry, as they involve the intimate contact of magnetic media with aluminum alloys. NIST will identify and study the measurement requirements; for example, NIST will modify its scanning tunneling microscope (STM) into an atomic-force microscope configuration to aid in these investigations.

Measurements on Advanced Media

New magnetic storage media are being developed and introduced, at least some of which will have market implications in the 1990s. NIST will conduct measurement research to support the introduction of advanced media types such as perpendicular recording, permanent magnet particulate, and magneto-optical. NIST will also study measurement problems relating to head systems, track densities, etc.

High-Performance Electronics

Major advances have been made in a wide range of magnetic materials over the last decade. The resulting new capabilities impact the design and production of advanced electronic systems and instrumentation. Very low temperatures, high frequencies, regions of very high and variable magnetic field are examples of new environments that now need to be considered for magnetic materials and devices. Measurement technology has not kept up with either the advances or the applications. As a result, a wide range of producers and users of electronic systems need NIST help in marketplace measurements supporting for example: magnetic ferrites for microwave applications and other electronic instrumentation; conventional ferrous alloys and specialty alloys such as metallic glasses and the nickel-based superalloys; permanent magnets, ranging from conventional Alnico through the newer samarium cobalt to the revolutionary rare-earth-based materials such as NdFeB; and superconductor applications in which the hysteretic behavior of the material is the controlling feature for applications in medical diagnosis or particle physics (i.e., Superconducting Super Collider).

Examples of the NIST response include the following. NIST will study the characteristics of powder materials that lead to measurement problems, such as the effect of powder formulations on coercivity, anisotropy, energy product, and magnetization stability at both low and high temperatures.

NIST will also investigate ferrite materials with its new variable-frequency radiofrequency permeameter to discover the source of the observed wide variation in the measured high-frequency magnetization. Magnetostrictive effects in amorphous alloys are also important and NIST will study the measurement implications of these effects at a later stage in the effort.

Instruments for determining magnetic properties require calibration over new ranges to support applications of magnetic materials and devices already identified and advanced applications just now emerging. For example, the advent of amorphous ferrous alloys and high-temperature superconductors has resulted in an increased demand for calibration standards for ranges of field, temperature, and magnetic susceptibility not previously felt to be of

importance. In response, NIST will develop artifact standards for the calibration of temperature-variable magnetometers and susceptometers. NIST will also undertake a program of theoretical evaluation of magnetometry to better understand the problems introduced by the measurement system and the sample geometry due to demagnetization and field images. Both SRMs and standard methods for measurement would be outcomes.

Because industry needs guidance for applying the many new measurement methods now available to new materials, as well as to old, NIST will review definitions of fundamental parameters and prepare and publish a comprehensive handbook on magnetic measurements.

Data on, and measurement methods for, very-low-level magnetic effects in materials not commonly regarded as magnetic, such as fiberglass epoxy, are needed by organizations developing sensitive magnetic detection systems for medical, NDE, and military applications. NIST will study these effects, identify marketplace measurement implications, and develop responsive test methods.

High-Efficiency Motors, Generators, and Transformers

Concerns for efficiency have lead to applications of new magnetic materials in products ranging from fractional-horsepower motors to multi-kilovolt-ampere power system distribution transformers. In vehicular and aircraft transportation systems, for example, there is need for electric motors and generators that produce maximum output for minimum weight. In power transformers, the concern is loss; it is estimated that the average annual capitalized cost of losses in transformers in the United States is about $2 billion. "The economic impact of power transformer losses is at a state where the cost of evaluated losses over the lifetime of a power transformer often rivals the initial price of the transformer."[8] The corresponding measurement needs include support for parameters discussed in earlier sections, together with the nature of the NIST response (measurement services, test method development, reference artifacts, as appropriate). NIST will also identify special needs and implement responsive solutions. For example, NIST will develop new methods for determining magnetic properties of the magnetic steels and new amorphous materials, such as core loss. NIST will develop a temperature-variable yoke magnetometer for small samples as a key development for these investigations. Existing techniques require very large samples, but the yoke configuration is essential to eliminate the very large demagnetization corrections required by other methods in high-permeability materials. NIST will also develop methods for evaluating the effects of very high stresses (as encountered in large magnets) on magnetic properties.

Nondestructive Evaluation

Nondestructive methods for evaluating structures and artifacts are becoming increasingly important to the nation's economy, for example to increase

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[8]NBS Technical Note 1204, Oskars Petersons and S.P Mehta, Calibration of Test Systems for Measuring Power Losses of Transformers (August 1985).

efficiency in manufacturing by identifying flawed starting materials and to promote safety in air travel and other transport modes by detecting incipient failure sites without requiring disassembly. Many of these methods depend on eddy-current techniques and hence on magnetic measurements. In response to needs of the nondestructive evaluation (NDE) community, NIST will develop methods for standardizing and calibrating eddy-current NDE probes and methods for characterizing advanced ferrites for these probes.

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This NIST Internal Report has been prepared by the Center for Electronics and Electrical Engineering (CEEE) within NIST. The report identifies emerging technologies in electronics that CEEE believes will require increased measurement support from CEEE in coming years. The emerging technologies described here are new to the marketplace or are experiencing major technological advances.

This report is an internal planning document. The document is designed to stimulate feedback that CEEE needs to refine its plans for developing measurement capability to support emerging electronic technologies that are important to the national interest.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Bioelectronics, Center for Electronics and Electrical Engineering, High Definition Television, Integrated Circuits, Lightwaves, Magnetics, Microwaves, National Engineering Laboratory, Optical Fibers, Semiconductors, Smart Systems, Superconductors, Video Technology

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Mr. WALGREN. Well, thank you very much. We appreciate your cooperation.

The Chair would recognize the gentleman from California, Mr. Brown, for questions.

Mr. BROWN. Gentlemen, I am impressed by the testimony that you have offered, and I don't sense any substantial disagreement amongst any of you. I think you all agree that we have to maintain adequate funding for the core functions of the NIST because of their importance in the various ways that you have mentioned and then to seek additional ways of implementing the new responsibilities which have been placed on NIST, which are equally important.

I am impressed, Mr. Richardson, by your proposals for establishing the network that you have mentioned. It seems to me that this fits right in with the thrust that this committee has been pushing for so long for more effective technology transfer and for linking private and public activities in order to achieve that.

I would ask one question here with regard to the general scope of these centers that you have suggested at the local level, and that is whether or not that you envision these as having a role not just in automated manufacturing but the broader concept of which automated manufacturing is a part, which is improving the quality of American manufacturing processes, which may include the more effective use of computers, better scheduling, in some sense possibly even better ways of organizing industrial activities.

Would that kind of information be available as an adjunct to what you are proposing here? Could we broaden that kind of a concept?

Mr. RICHARDSON. Yes, sir. What you are suggesting is an essential part of—has to be an essential part of the plan because when—basically starting with the problem—when you work with a small company to improve its competitiveness, even if you start with the notion that if we can put X amount of hardware into the plant it is going to operate more effectively, you find that you have train its workers, you have to reorganize its processes, you have to, in effect, reorganize in many instances the way management approaches its business, and very often you find when you do that that you don't nearly need so much hardware as you thought you needed.

So we envision this—for example, in the automation equipment suppliers in the lower left corner—we see that area as including not only hardware and software vendors, but training experts, consultants, and so on, and those are in effect the areas that these local centers are already providing services in the areas you suggest.

Mr. BROWN. The question you are going to get as you move ahead with discussions on this is going to get down to the bottom line. You know, where are the dollars coming from, how much is it going to cost?

It would seem to me that there would be a very, very real selfish interest on the part of the equipment suppliers and service suppliers in facilitating this kind of a development as a way of more quickly reaching the market which they are trying to reach.

Mr. RICHARDSON. Absolutely.

Mr. BROWN. And if we could get some commitments of that sort with regard to financial support from those who would benefit from this, I think it would make it easier in these tight budget times to get some commitment from the government.

We assume that the government would have to be involved, but that there would—the federal government, but there also would be interest on the part of state government, local educational institutions and that sort of thing because it fits so well into everything that they are proposing.

I am pleased that you have that broad concept of it.

Let me ask Dr. Drew. I think we are making a little bit of progress in conceptualizing this idea of the role of the federal government in technology. I see some minuscule progress being made here, and I like the suggestions that you are making to incorporate this function in the Department of Commerce with a Technology Administration, and I see no reason why that wouldn't be a logical extension of the way we are moving at the present time with what we have put in the Trade Bill, and so forth.

What I am concerned about is how do we get the Administration to support the initiatives that we have already embodied in legislation, including the Trade Bill, but going back to Stevenson-Wydler, and other things like that, and I am not assuming that this Administration is necessarily going to be opposed to that. It may be that it just hasn't yet reached the point in developing its policies where it has attacked these problems.

What can we do about that?

Dr DREW. Mr. Brown, I share a sense of frustration about getting the message across.

A part of the current situation, I think, is the key management team that would be necessary in the Department to become an advocate for this, just isn't there in place.

Mr. BROWN. Yes.

Dr. DREW. And it seems to me that a message from this committee would be helpful. Certainly I believe the IEEE feels a certain responsibility to try to create some of the intellectual content. As you say, shaping just exactly what that government role is in this area of technology is not an easy job because of the importance of the private sector in all aspects of it.

Mr. BROWN. Right.

Dr. DREW. Our concern has been in the past that the Department of Commerce has been a particularly strong reed on which to rest this particular burden.

Mr. BROWN. Right.

Dr. DREW. It was mentioned earlier, and I was quite interested to listen to the comment about fire research in the Department of Defense. It turns out that when IEEE was interested in an optical electronics center, when we looked around at places in the federal government with the dynamic, forward thrust and ability to use the funds—to obtain them and use them effectively, we wound up at DARPA, reluctantly because we felt that it probably would be better if it were sponsored somewhere else, but there wasn't that other sponsor there.

And I think if we can try to create that in the Department of Commerce it will be a much healthier situation, and I would hope that this Administration certainly is moving in that direction.

Mr. BROWN. I am going to make a suggestion to you in lieu of additional questions. Each of you represents very important national organizations in the engineering technology, metrology field, and I was impressed by the earlier testimony with regard to the statement that Congressman Walgren made in connection with fire services, and so forth, and the idea that they were going to have a large public event in which they would honor distinguished members of Congress.

I would like to suggest the possibility that this would be an appropriate for each of the national organizations to in some way focus national attention on these needs through an event at which they would invite the President or honor the President or honor Senator Hollings or honor Congressman Walgren, and we have a series of these over the next six months focusing on the—not a narrow focus, but the emerging need obviously seen now to regain America's technological leadership and the contributions being made to it, in the hopes that this would generate a public media focus on this which would get to the attention of those people who advise the President and the President himself, because right now we are going on automatic pilot.

OMB is just repeating what they have done before on these budgets. They have not been given a guidance as to where this country ought to be going, and they shouldn't be the ones who generate that.

Both the Congress and the President and the top policy officials should be doing that, and we need to sort of force that by putting the spotlight of public opinion on it in a constructive way. I am not urging anything here that is underhanded or nefarious, but we need to recognize that we need a policy shift, and you gentlemen who represent constituencies that run into the millions collectively and who are deeply involved in this can help, and I would like to suggest that you put that on your agenda to think about.

Mr. WALGREN. Thank you, Mr. Brown.

The gentle lady from Maryland, Mrs. Morella.

Mrs. MORELLA. Thank you. Thank you, Mr. Chairman. It is a pleasure to be here at this hearing on such an important topic.

First of all, referring to Mr. Rice's statement, he uses all these aphorisms in there.

I used to think that the NCSL was the National Conference of State Legislatures until I, you know, came to Congress, and now I know it is the National Conference of Standards Laboratories, and I also know that the adage that I came away with here is if you can't measure it, it isn't there, and I think you repeated that adequately.

Also, I am concerned—you talk about, as Lincoln said, "Before we decide where to go and how to get there, we must first know where we are and whither we are attending." I didn't even know he said that, but that is good.

You have talked about the lack of measurement capability at NIST, and you said it has sometimes forced you as industry to use the laboratories of foreign nations for calibration services.

Can you tell us a little bit more about that and then elaborate a bit on the recommendation you made as a result of that?

Mr. RICE. The studies that our National Measurement Requirements Committee made disclosed that a number of companies in this country could not get measurements of one kind or another at the Bureau. A couple of years ago it was in microwave. There are other areas. There is a power sensor, I think, that is actually made and measured—and it is used in a major program—that is actually made and measured in China.

There was also a problem of turnaround time. That has been largely corrected, I think, in the last two years. But people would have to wait three, six, eight months with their standard back at the Bureau and unable to make the measurement transfers that we had to make in our companies. They would go to Canada because it was closer and cheaper, cheaper, cheaper, less expensive in terms of time and in terms of the cost.

Now, they have since added a surcharge to U.S. buyers of their service. So it is a little more price competitive today than it has been.

Are there any others that you can think of, Gary?

Oh, yes, good point. We can give you specific details on that in a written response if you would care.

Mrs. MORELLA. I would be very interested, and I think, Mr. Chairman, the committee might well be, too, because in terms of one of your remedies you said if they were to do an assessment. It sounds like an assessment has not heretofore been done.

Mr. RICE. Well, they have started. We have made one about our view of the deficiencies from industry's standpoint; that is, the industry calibration laboratories.

I mentioned this report that I just saw this week that the Bureau has put out, the CEE, on emerging technologies in electronics, and that is certainly part of the problem. I haven't seen such an analysis in the other centers, and that is what I was asking for in that statement.

Mrs. MORELLA. I would be very interested, and I think the committee would, in terms of where you see these deficiencies, possibly what more could be done?

Did you want to comment on that, Dr. Drew? I saw you nodding affirmatively.

Dr. DREW. I was seconding the concern about microwave measurement standards, for example, and the result of a lack of vigor, shall we put it, in pursuing the very high frequency regions, which have been largely now pushed overseas, and in addition to that, we are also discovering in other areas, such as the open systems work in the computer area, European leadership in developing commonly accepted standards in this very, very important area economically for us and in terms of its benefits for productivity.

The shift to other nations' leadership I think is a matter of some concern to us.

Mrs. MORELLA. Well, I would be interested again for your additional comments in terms of what we can do to enhance that or correct that problem.

I understand, also, that before I came here, Dr. Drew, someone mentioned to me you talked about personnel, and that is called to

my attention because I am very interested in it and have a bill in and working with others in terms of trying to be able to recruit, retain.

I understand you have a rather innovative program. Would you share it with us, or recommendations, ideas?

Dr. DREW. I think that would be attributing too much to my remarks and to our view of this. It is not really our innovative program. I was referring to the authority which has been provided to the Bureau, or the NIST to apply an innovative personnel management and reward program within the Bureau structure, but that it had been not funded in the sense that they were given the authority but they were told to take any additional funds that might be applied out of their existing personnel budgets. At that point I recommended that there be an addition of about 2, perhaps $3 million to give them the additional flexibility to really use this program.

Mrs. MORELLA. So you are saying we gave it to them but we took it away because NIST does have that program?

Dr. DREW. We didn't give them adequate flexibility to apply the program.

Mrs. MORELLA. Adequate flexibility or adequate money?

Dr. DREW. Well, the money is what gives them the flexibility.

Mrs. MORELLA. The flexibility.

Dr. DREW. Yes.

Mrs. MORELLA. Okay, good.

Thank you, Mr. Chairman.

Mr. WALGREN. Thank you, Mrs. Morella.

The gentleman from Pennsylvania, Mr. Ritter.

Mr. RITTER. Thanks, Mr. Chairman, and I want to apologize to you and to my colleagues and to the witnesses for not being here for this excellent testimony. We, across the hall, are conducting a hearing of my Commerce Consumer Protection and Competitiveness Subcommittee, on which I serve as Ranking Member, and it is far more contentious than this hearing. These hearings are usually quite bipartisan in nature.

So I am depending on my colleague Chairman and colleague from California and colleague from Maryland to really carry the ball here, and we do share a great deal in the science and technology in that regard.

I would like to also welcome Ralph Richardson, who I have been working with over the last year and have been intrigued by the ideas that he is putting forth, working with the actual industry in an activist fashion, in a mass fashion trying to transfer technology into local and regional settings.

You have a technology communications network, Mr. Richardson, on the last page of your testimony. At the top of it you have the U.S. Department of Commerce Technology Administration. There is a dotted line there between the Automation Group.

But if you had your druthers in staffing that situation at the Technology Administration and in advising it as to how to move forward with your model, what would you do? What would the approach be to drive this thing forward or to help drive it forward?

Mr. RICHARDSON. Okay, if I understand, we are viewing the liaison office as a private sector activity.

Mr. RITTER. Yes.

Mr. RICHARDSON. We are looking at it in the sense that when this lower triangle is set up with that private sector initiative taking advantage of all the existing trade association involvement, state, community college associations, and so on, activities in this area, that there then should be an interface—is the best word I can think of to use—an interface, an active interface with some part of the Department of Commerce whereby all the various activities in the federal government that pertain to this problem, the programs that could be helped in this area would be funneled through this office of the Department of Commerce into the liaison office and out into the appropriate areas of the private sector or the state or trade association levels.

Conversely, we are aware that it is now felt it is very important for the Department of Commerce to gather as much information and knowledge as they can about what is going on in this area of technology transfer, and we see also, therefore, that the liaison office could feed from its experience the knowledge it gains into the Department of Commerce for its benefit.

So we see it as a two-way extension of this communications network.

Mr. RITTER. What, thus far, has been the response from the Department of Commerce?

Mr. RICHARDSON. We had a meeting about two weeks ago with Dr. Ambler, who is Acting Undersecretary of Commerce for Technology Administration, as you know, and several people, his colleagues from NIST and from the Commercial Affairs. Their response was very enthusiastic.

I think probably the best way to describe where we are now is everyone who potentially is to play a role in this area from the community people we have talked with to the trade associations to the vendors to the state government people, particularly in Pennsylvania—we have been working with Jacques Coupel, who has offered to work with us in the nine centers set up in Pennsylvania to help us learn how this can work better—everyone involved is enthusiastic.

We are in a state which is a wonderful state to be in. Now, we are getting down to the nitty-gritty of how do we actually make this thing work.

Mr. RITTER. The tough part, yes.

Mr. RICHARDSON. And this is the tough part.

Mr. RITTER. But I do want to commend you because what you are talking about basically hasn't been done—or maybe it has. Are there any other models somewhere else in the economy?

I mean, I think it is a great idea and it is essential because there is a chasm between what is out there and what is used.

Are there other models?

Mr. RICHARDSON. We are not aware of one. This model that we have here evolved out of a series of discussions and earlier, even more primitive models to arrive at this point, and so what we have presented here is really where we have got to from the point of saying these small companies need help and these local transfer centers appear to be the best way to provide that help; what can we do to make this more effective.

Mr. RITTER. Where do these NIST regional manufacturing technology transfer centers fit in? There's three of these. It is not clear as to what the future of the program is in terms of expansion.

Mr. RICHARDSON. We would see the NIST regional centers as being up at that state level. A lot of this is just shorthand. We see, for example, at the state regional level that would include the state groups that are sponsoring these local centers, we see it as any regional activities, such as the Hollings bill, NIST activities that are sponsoring local—as we understand it, they are going to in turn general local centers in their region.

Mr. RITTER. So that the basic mechanism for the technology transfer is really on a state, regional, local basis down more at the grass roots closer to the need?

Mr. RICHARDSON. Exactly. We are anxious to help any center that is trying to do this kind of job, whether it is a state or whether it is a community. There is an Alliance for Progress community college group that is very active in this area. That Alliance for Progress would be at this—from our perspective in the state, regional grouping area as a group we can work through to reach many local centers.

Mr. RITTER. I have one last question, and it is for Dr. Drew.

I have been talking about this idea of changing the reward system for people working in the federal government—I think it is in store really for all levels of government, but our purview is the federal government—to institute more flexible reward systems within existing agency budgets on a larger scale.

There has been some flexibility, I believe, at NIST, if I am not mistaken, but there is a real problem with flexibility at the top, although there is some flexibility there. I guess there are some other ways you can deal with that.

But how does IEEE view the idea of some kind of reform program for flexibility and reward systems for government employees?

Dr. DREW. Mr. Ritter, we strongly encourage this type of flexibility and program for areas where there is a strong need for specialized expertise that commands a premium in the private sector because of its rare and special nature as well.

The federal system doesn't lend itself to that very easily, and therefore we have been particularly encouraged by the experiments that were done early on in the Navy lab system, and we strongly supported it in NIST. I think our point was that we would like to see it more adequately funded, and at the risk of mentioning that again, we are suggesting that a very modest increase for this purpose of something on the order of 2 million or slightly over that would help that flexibility tremendously.

Mr. RITTER. Of course, you couldn't isolate out agency by agency. I think what we do have is the possibility of within agency budgets giving management the opportunity to be flexible the way flexibility exists in industry where there is growth. I think it is important.

Okay, thank you, Mr. Chairman.

Mr. BROWN. Mr. Chairman, could I make an additional comment?

Mr. WALGREN. The gentleman from California.

Mr. BROWN. Mr. Ritter's discussion with Mr. Richardson leads me to offer this.

As I think I indicated to you, one of the consistent concerns of this committee for the last 20 years has been the improvement of the technology transfer process, beginning with our concern with NASA and its technology transfer, technology utilization program, and it has a program. NIST probably has the best program in the federal government because of the close way in which it interacts with industry.

But through our committee's funding of these technology transfer programs in the enactment of the Stevenson-Weidner Act and various other things, we have created what you might call the vestiges of the framework of such a program throughout the federal government.

What your proposal does really is in a comprehensive way seek to establish a channel whereby this can be transmitted throughout the U.S. industrial system where it is needed the most, small and middle sized industry—the big companies establish their own links and do a pretty good job of it—and to tap into the resources of state and local agencies, which have similar concerns about disseminating this.

But we would need to build on those structures already built in NASA and Defense and NIST, and there are other agencies that we could think of. But they need this window or channel through which they can more widely pervade the industrial structure of this country, and I think that is one of the great merits of the proposals that you make.

Thank you.

Mr. WALGREN. Thank you, Mr. Brown.

I wanted to ask Mr. Ling. In your statement you raise the thought of Europe being integrated into a single market and the implications that might have for what standards we make in this country.

What do you anticipate down that road, and is there a specific response we should be making to that?

Mr. LING. Well, I was stating a general position, that one of the tools for competition or warding against competition is by having separate standards, the possibility of differing national standards, and we need to aggressively watch out that it does not happen in all areas where there are potential business segments that are, you know, economic benefits.

Mr. WALGREN. Are we in the position to lead in the standards setting effort so that regardless of what they do that their systems would not be incompatible to ours?

Mr. LING. I am not an expert on that. On the other hand, having been a member of the ASME Standards Group, which has a very large standards activity of all the professional societies, I would like to think that we—so far we are still leading, but rapidly diminishing in influence, if I may say so. It probably will invite some objections to that. That would be a personal observation.

Mr. WALGREN. Are there particular responses to that that members of the panel would suggest at this point?

Dr. DREW. Mr. Chairman, part of my testimony includes a recognition of this problem, dealing with the growing trend in Europe to build a common standards process and to adopt more and more

broadly applicable standards which are European generated and European applicable.

The U.S. has enjoyed the sort of leadership role largely because of the size of our market, and market size has been a very large determinant. The European market, when you start aggregating it as they are tending to do, will make the European standards setting process a very formidable part of the standards picture worldwide, and one of our problem areas, I believe, is that the NIST budget has not included adequate funding for strong representation of U.S. interests at critical times in the European standards organization and in the processes which are, I say, becoming better and better integrated in Europe.

To me, I think we have to try to be a stronger participant, to recognize our concerns and have them represented adequately in these forums early on in the process, or we are going to suffer from this in the future even more than today.

Mr. WALGREN. Well, we want to encourage NIST to pursue that.

Mr. Rice, you made a stab in your statement of measuring sort of the overall shortfall in, as I understand it, the basic measuring responsibility that the Institute has.

Now, am I right in you're suggesting something in the range of $50 to $75 million over five years to restore this? Is that in the whole range of the basic measuring function or is that just in an area that your organization might be particularly interested in?

Mr. RICE. It is in the area that our organization is interested in. It is derived from the report, these eight sectors, I believe, that are mentioned in our blue book, and the high component in that is microwave. About half of the need that we see is in the microwave arena.

Mr. WALGREN. I see. You indicated four areas—flow measurement, atmospheric, microwave, and international standards coordination—and that is just in your area alone, is that right?

Mr. RICE. Those four were merely the first four priority areas out of the 154 that we have identified. Those general areas were categorized for publication as our highest priority areas.

Mr. WALGREN. But I guess my point is that is just a portion of the basic measuring function——

Mr. RICE. Yes.

Mr. WALGREN [continuing]. That you looked at.

Is there some way that we can—how can we make a good assessment of what the level of effort should be across the measurement function?

Here we are urging them off into technology and things like that, but all wanting not to prejudice this basic function that seems to be so important.

How can we measure what that should be?

You also indicated that one rough rule of thumb would be if industry had expanded its R&D by two times in a certain time frame then you would expect the standards function in order to keep up with the dynamism of that doubling I gather should also double?

Mr. RICE. It certainly shouldn't stay flat. Yes, Mr. Chairman.

Mr. WALGREN. Is there any way to estimate what that might be and how can we really set ourselves a good target rather than be

trapped in these incremental changes that OMB suggests and then that we have to measure ourselves by?

Mr. RICE. Perhaps we do what Mr. Brown said and double the budget and then find the uses for it. That is probably not the best way.

This book here is an excellent start because it identifies the emerging technologies that the Bureau sees, and they have had some consultation I believe with industry to derive this report. It is just not yet comprehensive across the whole Bureau. It is only in one center. It is an outstanding start.

Mr. BROWN. Would the Chairman yield to me briefly?

Mr. WALGREN. I yield to the gentleman from California.

Mr. BROWN. I am not so naive to think that you can just throw out a doubling of the budget and expect to get an automatically sympathetic response. What we would do in this committee is probably, with the aid of our expert staff and relying on the testimony of our expert witnesses, create a carefully contrived, fully justified budget authorization which would coincidentally be twice what we are doing. [Laughter.]

Mr. RICE. I understand, Mr. Brown.

Mr. WALGREN. Any other suggestions on how you would look—this focuses on the new emerging technologies, but that doesn't help us, does it, with what the core effort should be?

Mr. Ling.

Mr. LING. Well, if I may just comment on that. Again, I agree. I think the factor of two is a good one because at this moment, in spite of the Trade Bill, NIST is still in this core business with growth into newer areas, such as some of the new effort that has been started, and I think that is a good way to start a new activity. The Advanced Technology has to be something quite different, as yet to come.

Mr. WALGREN. Well, okay. Well, let me thank you all on behalf of the committee for being a resource to us. We appreciate the effort that you have gone through to make these submissions, and we look forward to talking to you in the future as we develop them.

Thank you.

Well, let's turn to the next panel—Arnold Braswell, William King, Francis McGarry, William Connolly, and Joseph O'Grady. If you folks could come forward.

We appreciate your patience and your having come this morning. As I said before, written statements will be made part of the record, and you can feel free to focus on individual points that you would like to underscore in the five minutes or so that we really should try to stay within if we are to get through the number of witnesses and meet the other commitments that members have today.

So let me start with Mr. Braswell, who is the President of the Air Conditioning and Refrigeration Institute.

Mr. Braswell, welcome to the committee.

**STATEMENT OF ARNOLD W. BRASWELL, PRESIDENT, AIR CONDITIONING AND REFRIGERATION INSTITUTE, ARLINGTON, VA**

Mr. BRASWELL. Thank you, Mr. Chairman.

My written statement discusses what you asked us to do. That was to comment upon the CFC phase-out in response to the ozone problem and what is the role of NIST in relation to that, what our views are on that.

I will summarize my written testimony briefly for you.

We are here because we have a problem, and the problem is one that has become more acute in recent weeks. The problem is that we are going to have to phase out the existing refrigerants which are used in the support of our equipment.

The equipment that my association represents is the central air conditioning equipment and the commercial refrigeration equipment that is used throughout this country and, indeed, throughout the world. In fact, many of our products are exported.

We do not cover home refrigerators and freezers or window air conditioners or automotive air conditioning. That is covered by a different association, but all other types of refrigeration and air conditioning equipment are covered by our association.

And all of this equipment uses refrigerants which are critical to the efficiency and the performance of the equipment.

The CFC refrigerants that are used in this equipment are to be phased out, and at the present time, based upon international protocol, we expect to be down to a level of 50 percent of the 1986 production by the year 1998. However, there is now general agreement among nations and, indeed, President Bush has only recently announced that we should support the phase-out, the 100 percent phase-out of these CFC refrigerants by the end of this century if substitutes can be found.

And that is the crux of the problem, finding substitute refrigerants to support not only the new production equipment that we must design and get into production in the next decade, but also substitute refrigerants to handle the very large inventory of installed equipment which is used throughout this country.

And we are talking here about maybe $100 to $150 billion, not million, billion dollars worth of installed inventory of equipment in supermarkets, convenience stores, restaurants. We are talking about the large chiller machines which are used to air condition large buildings, such as those on Capitol Hill. There probably are 15 or 20 of these large chiller machines which are used for air conditioning purposes and without which you all would find it very uncomfortable here in the warmer months, and in fact those machines in many places are used more than six months of the year to make our large office buildings and hospitals habitable for a large portion of the year.

So the equipment we are talking about is very important, and it is important not only to our standard of living, but to our economy because much of it is used also in industrial processes and food processing. We are talking about equipment that is used also in distributing our food and getting it to market, the refrigeration equipment in truck trailers, for example.

Now, in our association and in our industry we support the global action that is needed to get rid of these refrigerants as soon as we can if they are indeed determined to be damaging the ozone layer, and that appears to be the case, and we are working very hard to find alternatives.

It is a difficult task because we have been depending upon these fluorocarbon refrigerants for many years, and we must now find new substitutes. There are some substitutes available and some candidate substitutes, but they are not yet proven.

The best substitute that we have actually is HCFC–22. It is actually a refrigerant that causes very little depletion of the ozone layer. It is commonly used today in much of our air conditioning equipment. For example, it is used in all of the home air conditioners. It could be adapted to be used in some of our refrigeration equipment, but it is not likely to be the optimum refrigerant for that purpose.

It is important to protect the status of that particular refrigerant because it can be adapted if necessary as a substitute. What we are looking for are other refrigerants which are better suited for these various applications, which are more efficient, which are not toxic, which do not attack the materials used in our systems or the lubricants used in our systems, and that search is very much underway at the present time.

The problem is that with the amount of time that we have we do need some help. NIST is one organization that is available and that can assist in this effort.

In other words, we have a time problem. We in our association have developed a research plan which addresses, among things, the issue of finding new refrigerants and testing them and getting them into new equipment.

We have discussed that research plan not only with NIST, but also with DOE and EPA, and they are cooperating with us in trying to develop a research program for the future.

NIST we think has a very significant role to play in this effort. First of all, they are well-equipped and probably the best equipped organization to measure and define the thermal properties of new refrigerants. They are doing that at the present time, but we need to accelerate the rate at which they are doing so, and in fact they have agreed to accelerate that to the extent that their resources permit.

They also are setting up a repository of information about new refrigerants which companies in our industry have agreed to contribute to—an unusual development, by the way—and that information will be made available then to all persons or all companies that would like to call on that information, and NIST will maintain this function, which is a very useful function.

NIST is qualified to do some work to study and develop new refrigerant mixtures which might be applicable and useful in the future and in new equipment.

And, finally, they can develop standard test methods for testing chemical compatibility of new refrigerants with the lubricants and other materials in our equipment, and they can help in coordinating government research in this direction.

We think that NIST needs funds for this effort. At the present time there are no funds identified in the NIST budget for refrigerant research. There was about a quarter of a million, but that has been dropped. We don't think that even a quarter of a million is near adequate. We think that the NIST should have about $3 million a year for the next two or three years to help pursue this very

critical program that is addressing a very important environmental issue.

It is not only an environmental issue of importance to this country. It is also a global environmental issue. In fact, it is a global issue, and in our opinion the NIST is one of the agencies which can be very helpful in getting us solutions to this problem in a very timely way.

We also think that DOE and EPA should be expending considerable resources, and we are recommending increased funds in DOE for this purpose.

I would like to comment specifically on one need which is very important, and that is the support of the installed inventory of equipment. I mentioned earlier the large amount of equipment which we have already installed in this country.

The problem is that if we develop new refrigerants for new equipment those new refrigerants will not probably be usable in the existing inventory. In fact, we don't yet know what new refrigerants can be used in the existing inventory, and there is a lot of work that needs to be done to develop substitute refrigerants which can take the place of the existing CFC refrigerants and which must be used for servicing the existing inventory.

This refrigeration equipment has to be serviced from time to time. It does leak, periodically has to be reserviced, or in some cases the system may break down and has to be reserviced, and there is going to be a need for continuing to service all of this installed equipment—and there is a very large amount of it out there—for many, many years. It will last for 15 to 20 years. In the case of large chillers, they may last for 25 years or more.

We are either going to have to use CFC refrigerants to do that and continue to produce those for that purpose, or else we will have to find substitute refrigerants which are compatible with that existing equipment and which will operate properly, and that work needs to go forward as well.

[The prepared statement of Mr. Braswell follows:]

ARI AIR-CONDITIONING & REFRIGERATION INSTITUTE

Representing Manufacturers of Heating, Ventilating, Air-Conditioning and Refrigeration Products

Statement of Arnold Braswell
President, Air Conditioning and Refrigeration Institute
Before The
Subcommittee on Science, Research and Technology
Committee on Science, Space and Technology
U.S. House of Representatives
March 23, 1989

Mr. Chairman and members of the Subcommittee. I am President of the Air Conditioning and Refrigeration Institute, known as ARI, the manufacturers' trade association of our industry.

I welcome the opportunity to discuss the challenges presented to manufacturers and to the public by the reduction and possible future phase-out of chloroflourocarbon (CFC) refrigerants. These refrigerants are used in a large portion, though not the majority, of the units manufactured by members of ARI. Our members do not include household refrigerator or automotive air-conditioning manufacturers.

Our industry endorses global measures to reduce as rapidly as possible the use of substances which damage the earth's ozone shield. ARI called for international agreement on such measures well before the signing of the Montreal Protocol. We agree with the need to reexamine the current reduction schedule in light of the latest available evidence. If the evidence convinces the scientific community and world leaders that accelerated phase-out is necessary, our industry will support that. We have no desire to continue using CFCs if we can find alternatives, and we are working hard now to find them.

But we must also consider the world need for efficient refrigeration and air conditioning systems — and the realities, especially the time requirements, of developing new equipment and converting the huge world inventory of existing equipment to new refrigerants. The task is enormous. We must proceed expeditiously but prudently. This equipment is used widely to preserve food, to keep our large buildings habitable and to support many industrial operations. Premature phase-out of refrigerant production, before all equipment is modified or replaced, would cause serious economic and societal damage.

Products of our member companies using CFC refrigerants include the following:

— Centrifugal chiller machines for air-conditioning large buildings, produced in the U.S. at a rate between 3000 and 4000 per year, with about 80,000 to 90,000 installed nationwide. These units last for 25 years or more.

— Refrigeration equipment used in supermarkets, restaurants, trucks, railcars and other industrial or commercial applications. An unknown number of units using CFC refrigerants, probably over four million, are installed nationwide. These units will last for 15 years or more.



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With replacement of worn components, such as compressors and motors, they will last much longer.

— Electric drinking water coolers, with perhaps six to eight million installed.

— Automatic ice-makers used in hotels, restaurants and other establishments, with probably over three million installed.

We believe that the above products account for about 10 to 15% of the total U.S. CFC consumption, a small percentage.

In referring to CFCs I do not include the hydro-chloro-flourocarbons, or "HCFC" compounds, which have very little effect on the ozone layer and are not planned for reduction. HCFC-22 is one of these, and it is the most widely used refrigerant in air conditioning systems. It is used in virtually all residential air conditioning, both central and room units, and a good portion of commercial systems. It is a potential alternative to CFC refrigerants in some applications, but this will require new or modified equipment. It is therefore part of the solution to the ozone depletion problem. For that reason it would be a mistake to begin considering possible restrictions now on this useful compound. That would be most counter-productive.

But HCFC-22 is not an efficient or economical alternative for some other major applications. Therefore, it would be a mistake also to base CFC reduction plans on the assumption that this alternative is readily available for virtually all uses. It is not.

The task of converting to alternative refrigerants is daunting. There are problems which have not been resolved with all potential alternatives currently being studied. Some are not efficient. Some are not chemically compatible with lubricants or other materials in current equipment. Some are flammable. Toxicity questions are not completely resolved for the new refrigerants and full toxicity tests will take years to complete. Few of the several new candidate refrigerants have been available for testing by manufacturers until recently, and there are some new candidates still not available in adequate quantities. There is growing belief that a sizeable group of new refrigerants, including mixtures, will be needed, but we don't yet know which will emerge as the choices. We must test them all carefully and choose wisely, for reasons of safety, equipment durability, energy efficiency and — last but not least — global competitiveness.

Manufacturers cannot develop equipment for new refrigerants until the above questions are resolved. It will then take time to design and test pre-production models. Then comes the process of retooling for production, which of course cannot begin until there is an assured supply of the new refrigerants in adequate quantities. Even if everything clicks we cannot expect equipment with new refrigerants to begin production before 1993 or 1994. It could be later. And there will have to be a period of transition for a few years beyond that. So we must expect to see some equipment with CFCs still being produced in the latter half of the '90s.

As far as new equipment is concerned, most in our industry believe that we will find alternative refrigerants and that we can phase out CFCs entirely in new products by the end of the century. That is our current expectation, though we don't yet have all the answers we need to describe how it will be done.

The most troublesome problem is the need for continued servicing of the large inventory of installed equipment with CFC refrigerants. We don't have the capacity to replace all of that equipment in a few years. We may or may not have the capacity to modify it sufficiently to accommodate substitute refrigerants. The modifications could be extensive — maybe prohibitive — for much of the equipment. We just don't know yet and it will be a few years before we do know what will be needed. We think its likely that CFCs in small quantities will continue to be needed for servicing installed equipment beyond the year 2000. Research and testing during the next two or three years will help us predict more accurately what can be done or cannot be done to phase out CFCs in installed equipment.

Manufacturers have been collecting data and conducting research on alternatives to the best of their ability in the last two years. Substantial funds are being spent this year, and these will be increased as testing and development accelerate.

Under normal circumstances our industry could do the necessary research and testing without any assistance, with equipment manufacturers and refrigerant producers working together. But there is too much to be done in a short time, to test and prove all the candidate refrigerants, select the most suitable and efficient ones for various applications, design and test new equipment, and retool for production. The process takes time — and money.

ARI has recently initiated an association research program and developed a research plan. The most immediate objective — though not the only one of the plan — is research on alternative refrigerants. The plan defines those tasks best performed by industry and those which could be done by government. And it lays out time schedules. While the majority of the necessary work to effect a transition to new CFC refrigerants must be performed by industry, government research can play a critical role in the initial stages, thereby helping to speed up the transition.

We have discussed our plan with DOE, EPA and NIST. They are working informally with us to refine it.

NIST has a crucial role. First, its National Engineering Laboratory's Center for Chemical Engineering has the needed expertise and the facilities to measure precisely all of the thermo-physical properties of the new refrigerants. This work must be done thoroughly and done early to permit the initial selection of appropriate refrigerants and the design of prototype equipment for testing. At the urgent request of our association NIST has recently agreed to accelerate its research on refrigerant properties this year if funds can be made available. This refrigerant research needs to be continued also through

1990 at the fastest possible rate. We need this data; in fact we could use it right now.

NIST also has plans to establish a national data repository on new refrigerants in the Office of Standard Reference Data, in its National Measurement Laboratory. We have asked NIST to expand and accelerate this data bank or repository to include much additional information pertaining to new refrigerants. For example we would like it to include the results of any known research on compatibility of new refrigerants with lubricants or other materials used in refrigeration equipment.

Chemical blends or mixtures of environmentally safe refrigerants expand the number of possible alternatives and offer the potential for "tailoring" the properties of refrigerants to meet design constraints and efficiency objectives. Simulation models and breadboard refrigeration systems in the National Engineering Laboratory's Center for Building Technology should be used to explore the potential usefulness of these refrigerant mixtures.

At ARI request, most of the major companies in our industry have already agreed to share much of their current and future research information on new refrigerants. They will do this by providing the information and data to the NIST repository where it can be filed with similar data from other sources and then made available on request to anyone who requires it. This will help to reduce duplication of important research and enable the industry and the government to use our research resources more efficiently. And industry, through ARI, will work closely with government agencies to help plan and coordinate industry and government research activities. Beyond that, industry will devote its efforts to developing new products using alternative refrigerants and to converting production facilities when the time comes.

We also believe that NIST can provide unique resources through its Institute for Materials Science and Engineering. That group can act as the government focal point for coordinating and funding government research which we believe should be conducted to help resolve questions of chemical compatibility between new refrigerants and the materials used in refrigeration systems, including lubricants. Additionally the Institute can develop a standardized test methodology for materials testing with industry guidance to insure that all test results are useable. There is much work to be done in this area before decisions can be made on alternative refrigerants. NIST is the best qualified agency to manage this research, much of which will have to be done in private laboratories under contract.

Because of the importance of this environmental issue, and the urgency of finding solutions as soon as possible, NIST should be provided with adequate funds to do the work that is needed. It's too important a matter to do otherwise. EPA and DOE, other agencies involved in this research activity, should also be funded adequately to assist in research on new technology.

We were surprised to learn that the very small funds previously planned for NIST refrigerant research — about one quarter of a million dollars — have been deleted from the proposed 1990 budget. That's a serious omission. Not only should those funds be restored but they should be significantly increased, so that NIST can conduct in-house work and also fund the contract research that is needed.

As a minimum ARI currently estimates that NIST should be authorized three million dollars a year for the next three years. After all the research needs are clearly identified even more funds may be required. Even if increased, the funds would not be large in comparison with other research programs. Given the nature of the environmental matter we face and the urgency of finding solutions, the Congress would be wise to ask NIST what they could effectively use and then authorize that or more.

The Congress should also look closely at research funds related to this effort in the other departments and make sure they are adequate. Our industry, through ARI, will work closely with these government agencies to help them plan research programs which are coordinated with industry research.

We must keep in mind the vast inventory of installed equipment which will continue to need servicing with either new or recycled CFC refrigerants until replaced. Many years will be required to replace all of it. Some in the industry believe we may find substitute refrigerants suitable as "drop-ins" for some of these units. We don't have proven drop-ins yet, and we may not ever have them for some of this installed equipment. It is likely that small quantities of CFCs will continue to be needed beyond the year 2000 to keep installed equipment operating.

Industry is working hard and will be heavily engaged for the next few years in finding refrigerants for new equipment and getting that equipment into production. Refrigerants being developed for new equipment designs will not necessarily work in current equipment. Government research is needed to expedite the search for substitute refrigerants for the installed inventory. We believe that DOE should significantly expand its limited refrigerant research program to meet this need. The objective should be to identify and then test promising substitute refrigerants, including new blends, in currently installed equipment. This testing could be done in U.S. government facilities. NIST can assist by identifying the refrigerants to test, based on measurements and analysis.

Funding required for such an expanded program would probably not exceed ten to twelve million dollars a year for two or three years. It is clearly in the public interest to find ways of reducing the dependence of equipment operators on CFC refrigerants while keeping this essential machinery operating until it is eventually replaced.

Summing up, Mr. Chairman, the makers of commercial refrigeration and central air-conditioning equipment are working hard to find new refrigerants. The chemical producers are working closely with them. It's a big task and will take time. We don't have the answers yet. We

must not give up our hard-won gains in efficiency, so we have to look at every possible alternative. We need time — the nation needs time — to make this conversion. We also need understanding. And the government has a role to play in research.

I thank you for the opportunity to discuss this important subject.

Mr. WALGREN. Let me, if I might, stop you there, and I apologize, but we can elaborate on that a little later or what you would like to add.

Mr. BRASWELL. That completes the essence of what I wanted to say, Mr. Walgren.

Mr. WALGREN. Very good.

Let's turn to Mr. King, and we will be able to get you in if we start now before we are going to have to suspend to respond to this quorum call.

Mr. BROWN. Mr. Chairman, that is not a mandatory quorum call. That is an optional quorum call.

Mr. WALGREN. I didn't hear the long bell, and I heard the number, which would mean my instinct is a five-minute vote would follow.

So let's get Mr. King in, and we have got enough time for you and then we will have to break at that point, and it will take us 15 minutes to get back at that point.

So, Mr. King, please proceed.

**STATEMENT OF WILLIAM B. KING, CHAIRMAN, BOARD OF DIRECTORS, NATIONAL INSTITUTE FOR BUILDING SCIENCES, WASHINGTON, DC**

Mr. KING. Thank you, Mr. Chairman. I am here in the capacity of the Vice Chairman of the Board of the National Institute for Building Sciences, and on behalf of the entire Board, we appreciate the opportunity to present our views on the proposed budget for NIST and, most specifically, the proposed budget for the CBT and the Center for Fire Research.

Our written statement contains a detailed explanation of all of the Institute's views, but this morning I would like to take my limited five minutes to concentrate some specific comments on the two centers.

In your consideration of the work done by these centers, I believe there are three questions that need to be addressed.

First, what is the true value to the nation of the work of these centers?

Second, can this work be done by others?

And, finally, what is the appropriate funding level for the centers?

As regards the first question, the Institute feels that the work performed by CBT and CFR is extremely valuable because it impacts the cost and the safety of all types of building construction. As a result, virtually everyone in the country benefits from the work of the two centers.

The Institute feels qualified to make this statement because for the past four years, at the direction of the Congress, NIBS has worked with the centers to survey the construction industry to identify the most needed fire and building research projects. In this effort we have queried thousands of engineers, architects, code officials, building regulators, researchers, owners, and building users.

This program is supported and made possible by hundreds of volunteers who donate their time and expertise to develop, refine, and

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set priorities for the research projects which we recommend to NIST each year.

Last year, for example, the Institute recommended 43 specific projects to NIST, and they were able to include 15 of these projects in their current activities. This cooperative effort has helped ensure that the limited NIST funds are spent on the nation's most critical building and fire research needs and on projects where the research results will have the largest and the most immediate impact on the building community.

The Institute's four-year experience indicates that the research efforts of these two centers are carefully targeted, well-managed, and of great value to the maintenance and improvement of the quality and safety of the nation's building environment.

As regards the question of whether the work performed by the centers can be done by others, the Institute believes that the answer to this question is clearly, no, it cannot. This evaluation is based on the fact that many of the building communities' most important research needs involve issues such as fire and earthquake safety, the cost and quality of construction, and indoor environmental health.

These issues are too complex and broad based and, as such, they exceed either the capability or the commitment of most private research organizations.

It is also important to note that there are 400 private sector organizations currently involved in the development and maintenance of voluntary and industry standards for the building community. These standards are based on test methods which are produced by CBT and CFR. These test methods provide the unbiased, nationally accepted tools needed to evaluate the thousands of products, materials, components, and systems which make up our total national building and construction industries.

The public interest requires the preservation of this unbiased, authoritative, nationally recognized research capability which the two centers are now providing to the nation.

Finally, as regards appropriate funding for the two centers, NIBS does not believe that any reduction should be made in the current funding levels and, in addition, we recommend in NIST's overall budget.

However, we are concerned that the total NIST budget be distributed in a way that does not weaken the many valuable contributions that the CBT and the CFR make to the building and construction industries. Therefore, the Institute would recommend restoring the budget levels for CBT And CFR to the fiscal '86 levels of $10 million and adding whatever additional funds are necessary to complete NIST's total mission.

Thank you for this opportunity.

[The prepared statement of Mr. King follows:]

TESTIMONY OF

THE NATIONAL INSTITUTE OF BUILDING SCIENCES

BEFORE THE

SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

of the

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U. S. HOUSE OF REPRESENTATIVES

MARCH 23, 1989

Mr. Chairman and members of the Subcommittee I am William B. King, vice chairman of the board of directors of the National Institute of Building Sciences. On behalf of the Institute's board of directors, I am honored to appear before you to present the Institute's views on the proposed 1990 fiscal year budget and programs of the National Institute of Standards and Technology (NIST).

The Institute's testimony will address primarily the National Institute of Standards and Technology's Centers for Building Technology and Fire Research, as it is from those Centers within NIST that the nation's building process benefits most directly. From the perspective of an organization authorized by the Congress to address the building regulatory process, the importance of credible and impartial technical research findings on such issues as fire safety, indoor air pollution, structural safety, material testing, and long term building technological needs cannot be over emphasized.

## Research Recommendations for the Centers for Building Technology and Fire Research

For the past four years NIBS has, as recommended by the Congress, developed near- and mid-term recommended research agendas for both Centers. In order to assure a sound basis for these recommendations NIBS has queried thousands of engineers, architects, regulators, researchers, building owners and managers, and other individuals and organizations responsible for important aspects of the building process concerning what research they need that would be appropriately investigated by these Centers. Hundreds have responded to the queries and many building community professionals have served on voluntary project committees to review, refine, and set priorities for the research projects recommended. Each year the Centers report to the Institute on the actions taken in response to the previous year's recommendations. This feedback continues to demonstrate the value of the Centers and in this area has confirmed the federal government's responsiveness to the voice of the building community.

Last year, the institute submitted forty three specific priority projects to the NIST recommending that they be accomplished in FY 89 or as soon thereafter as funding allowed. Of these, the NIST was able to include 15 in their research programs at the centers for building technology and fire research. NIBS is continuing its effort to identify research topics and is now in the process of collecting and evaluating building community suggestions for the two centers for FY 90.

As a consequence, building community professionals participating in the NIBS solicitation for research recommendations better understand and respect the role of the two Centers and eagerly contribute to the call for suggestions. Furthermore, during the past three years there has been a recognizable improvement in communications between the numerous building community sectors and NIST's Centers, and a significant growth in the use of the results of the Centers' research by the private sector.

## Traditional and New Building Community Needs

The building regulatory and procurement processes in the United States rely on the use of a wide range of technical criteria to achieve and assure adequate construction quality. It is essential to the national health and welfare that we learn more about and seek to improve the resolution of environmental health problems ranging from asbestos, radon and lead-based paint hazards to safety related fire and smoke toxicity threats. In order to improve the quality of life, it is equally essential that we better respond to building quality and durability needs in such areas as heat and moisture transfer in walls and roofs, and resistance to weathering of concrete and other exterior building materials. There are perhaps 400 private sector organizations responding to these and other issues by developing and revising voluntary and industry standards. Most rely on nationally acceptable methods to quantify the performance of building products, materials, components, and systems. The Centers have contributed significantly to this process by establishing, evaluating, and revising many of the test methods used. Each center is the only source of unbiased evaluation in its area since they have no vested interest in any particular product or manufacturer. Both test more thoroughly than could be afforded in a private laboratory because basic research is costly and there are too few customers to make it profitable. They essentially serve as a technically accurate source for testing methods development, for which there are few highly credible and readily available substitutes.

During this decade the redirection of the nation's available research resources away from building construction has eroded the nation's position as a world construction leader. Before even greater losses occur, it is important that renewed emphasis be directed to generic construction research. The Centers for Building Technology and Fire Research are uniquely placed to provide invaluable technical support for this goal. Liaison between the nation's building community and these research Centers through such private organizations as NIBS, professional societies, model code organizations, and voluntary consensus standards making and promulgating organizations as the American Society for Testing and Materials (more popularly known as ASTM), and the American Society of Heating, Refrigerating, and Air Conditioning Engineers serves to increase the Centers' value. The standards and research activities of these organizations demand accurate technical data on which to base decisions and required validation of test methods. Fulfillment of these needs is fundamental to building construction quality.

## The Effects of Funding on the Two Centers' Programs

Center for Building Technology: At the current funding level for the Center for Building Technology (CBT) only about half of the programs included on the research agenda recommended by NIBS last year are now underway. Further, several of the programs require multi-year efforts. Thus, with a reduced budget a major portion of the partially completed research may well be lost. On average, typical research programs cost from

$150,000 to $200,000 each per year. Under the reduced budget level outlined in your letter Mr. Chairman, the Centers will be able to act on only a very small portion of the remaining items on last year's agenda and on few if any of the recommendations being considered by the NIBS committee this year.

Specific programs that cannot be conducted under even the current level of funding include: 1) updating standards upon which to base water usage requirements; 2) developing test methods leading to improved sensors for control systems; 3) developing design procedures for masonry wall openings and the shear strengths of tall walls; and 4) developing design criteria for upgrading steel columns in existing buildings. These are but four of the ten recommended programs that cannot yet be undertaken. Without restoration of current funding, major portions of even the ten currently active programs will not be accomplished.

**The Center for Fire Research:** The work of the Center for Fire Research (CFR) provides a scientific and technical basis for reducing fire losses as well as the costs of fire protection. If the proposed funding cuts are approved, the Center would cease to exist as an autonomous activity, thus, depriving the nation of a focal point for further technical advances in fire safety research. The fire and smoke spread modeling program in development at the CFR is seen as an advanced tool for use by design professionals and regulators concerned with improving fire control and prevention in buildings. The data to support use of the model will be derived from the use of combustion toxicity tests similar to the Smoke Toxicity Test Method now under development by a NIBS working group as part of the Institute's Fire Hazards program. This is just one of the cooperative efforts between the CFR and concerned private sector organizations. Without maintaining at least current funding levels, this fire modeling program is expected to be severely reduced. Restoring the Center's budget to at least 1986 levels would hasten the application of the benefits this program will provide.

Nine of the programs now underway at the CFR comprise approximately half of those recommended by NIBS last year. At this level of effort work on the 1) toxicity of plenum materials; 2) developing the technology for false alarm reduction on residential smoke detectors; 3) control of fire spread through use of fire resistant barriers; and 4) fire system component reliability is not being conducted. These are but four of the eight programs that are being delayed, postponed or eliminated. In view of the nation's poor fire loss and safety record in comparison to other developed countries, the underfunding of these needed programs or the loss of this Center would be a serious blow to potential improvement of their level of effort.

In 1986, the direct appropriation portion of the budget for the two Centers was $10 million. In 1987 and 1988, this amount was reduced to $9 million. Since 1980, representatives of the Centers indicate they have lost approximately 50% of their base funding through budget reductions and

general increases in the cost of business. The proposed FY-89 budget cutbacks will eliminate many of the Centers' capabilities. A combined funding level of $10 million for both Centers represents about four cents per year from every American citizen to maintain these important activities.

## Responding to Building Community Needs

If the Centers' capabilities weren't readily available, responses to critical needs such as establishing and evaluating cost effective and accurate methods for on-site testing of lead-based paint, developing highly credible test protocols for air samples and bulk samples of asbestos containing building materials, and creating a modeling programs for better predicting how fire and smoke move in buildings would not be available to the building community. Such research is not often conducted by individual for-profit corporations because it does not promise a prompt return on investment. However, industry has often demonstrated its interest in and support for such public benefit programs when sponsored through general and shared support programs by trade and professional associations, independent institutions, and academia.

Another critical mission is the nation's ability o respond to events such as the DuPont Plaza fire in Puerto Rico and the fuel tank collapse in Pittsburgh. As disastrous as these incidents are, they can serve as "full scale" laboratories and contribute much to the scientific knowledge base that could help to prevent similar failures in the future. It isn't possible to predict the type, location, or timing of such events, but by maintaining knowledgeable and available response teams at these Centers, the technical information that could be learned from prompt investigation and analysis of such disasters would be beneficial to the nation as a whole.

## Response to Federal Government's Needs

In addition to direct appropriated funds received by the CFR and the CBT, we are aware that funds are transferred to these Centers by other federal agencies with construction related programs for the purpose of conducting research in support of their respective missions. It is important to recognize that many of the research efforts these agencies request are oriented to their specific focused problems, rather than generic research typical of the building process needs in general. Thus, direct appropriated funds are needed to continue current efforts which will result in broad benefit to the nation, as well as to insure that the depth and breadth of staff and equipment are on hand to accomplish agency needs.

## Research in Support of International Competitiveness

As the Institute testified last year, the nation's building process represents a significant portion of the U.S. economy. The nearly nine million people employed in building construction and the generated annual economic activity of approximately $400 billion, justifies a larger portion of the government related research needed to support its growth. Additionally, it is recommended that the enhanced National Institute of Standards and Technology's mission in areas of increased funding for international competitiveness be oriented to serving the building construction industry in addition to other important sectors of the nation's economy. If support for the fragmented building industry is not consistent with support afforded other segments of our economy, foreign competition will likely continue to increase its market penetration in not only products and materials, but also in construction and professional services. The Institute's research during the past year has identified significant foreign inroads into a number of the parts of the building and housing design and construction process.

## Recommendations

NIBS supports, in general, the increase in the NIST's overall budget. However, it is concerned that a portion of the expanded or new funding for certain programs seems to have been generated at the expense of programs supporting the nation's building process. Therefore, for this reason and for the other reasons included in our testimony, the Institute suggests eliminating the building and fire research budget cuts and at a minimum restoring the budgets for the Centers for Building Technology and Fire Research to their FY-1986 levels of $10 million.

Mr. Chairman, thank you for the opportunity to present the Institute's views on this important issue. If you or other subcommittee members have any questions, we would be pleased to respond.

Mr. WALGREN. Thank you very much, Mr. King.

At this point we have to suspend, and I think we will be suspending for about 15 minutes. So if you would, those yet to come, stay a little close and we will be back directly.

[Recess.]

Mr. BROWN [presiding]. The Chairman will be right back, but in the meantime let's go ahead.

Mr. McGarry, you are next. Would you proceed with your statement, then?

## STATEMENT OF FRANCIS A. McGARRY, NEW YORK STATE FIRE ADMINISTRATOR, ALBANY, NY

Mr. MCGARRY. Mr. Chairman and members of the committee; my name is Francis McGarry. I am the State Fire Administrator from New York State.

Also, for the record, I would like to mention that the testimony submitted today is also submitted on behalf of the State Fire Marshals Section of the International Association of Fire Chiefs, and my colleagues across the nation pretty well concur with the thoughts contained in the testimony.

I am here to speak on the budget for the Center for Fire Research and several other concerns regarding the center. My main reason for being here is that New York has had the experience of using the work that the center has done in the past to improve our fire protection policies within the state.

The movement for getting states to conduct fire research on their own is a movement that cannot succeed. The funds are not available, and in the past when states did research for providing a foundation for some of the regulatory programs they could turn to colleges and universities to provide that research. That is no longer feasible today.

When we look at the colleges and university research programs, they are not independently funded, but in many cases, in a fair amount of cases are funded through cooperative agreements with some of the industrial giants of our nation, and as a result, when government goes to ask for specific research projects to be conducted they face a significant dilemma, the dilemma being essentially that the colleges and the universities, with the continuing and ongoing funding relationships with industry, face, if not a conflict of interest, at least a conflict of commitment.

And government has a question that it must ask itself, to what degree are these researchers in the colleges and universities free to provide the support for the government projects when their ongoing funding and support is directly related to the industries that government may end up regulating with those projects.

So it is a bit of a problem in that respect.

The states really have nowhere to turn. They can't do it themselves, and in fact to have 50 different states conducting 50 projects on the same issues frankly could not be coordinated very well, and without any coordination it would be a waste of some of the scarce public resources we do have.

The only place we have to turn is the Center for Fire Research.

But, frankly, our position is that the research does need adequate funding. It is not that the fire protection officials are ungrateful for the work that this committee has done in the past, of restoring funding over the objections of others, but the problem of fire protection in this nation is as enormous as it is scientifically complex.

There are indications that the real fire loss for this country exceeds $60 billion a year. From our perspective, $60 billion a year is an awful, outrageous price to pay just to stay even. If we are destroying that much new wealth each year, we must create $60 billion just to replace that wealth that is lost.

We believe that funding in the neighborhood of $10 million for the Center for Fire Research to continue its work and to speed up some of the projects that are underway is most essential and it will provide a good scientific and engineering foundation for these fire protection policies that our states and our local governments must implement.

Fire protection today suffers from a lack of knowledge, a lack of good scientific and engineering knowledge. We know that fire kills, but we still don't know what it is that is actually doing the killing.

We call smoke inhalation one of our more causative terms. It is a beautiful term of art, but absolutely empty scientifically and diagnostically.

We know that fire burns very rapidly and ferociously, but we don't know enough of the why to prevent our building materials and our building contents from contributing and be major contributors to that process.

We have to prevent the fires, and we have prevent our materials and the things of our lifestyle from contributing to it.

Again, we reiterate that we believe that $10 miilion is necessary to maintain the efforts of the center. We think that is very small in relationship, one, to the loss and in relationship also to the overall budget and fiscal condition of our nation.

But lacking the scientific and engineering knowledge, fire protection officials are left to develop strategies that are based purely on experience. Experience being our only guide, we end up testing new strategies, new products in real life situations, and, frankly, it is killing us, literally killing us as a nation.

I would also like to speak a little bit about the merger of the Center for Fire Research, or the proposed merger, and the Center for Building Technology.

Frankly, we believe it is too risky, and we believe it is dangerous. The loss of focus and, as a result, the loss of energy to pursue the necessary public fire protection objectives of this country is a critical and a dangerous loss.

It weakens the vital commitments and the communication links between the fire protection community and the Center for Fire Research.

We believe that the Center for Fire Research and its objectives should be more aligned with the fire protection communities of this nation.

The Center for Building Technology, it has its objectives, and we believe there's merits there, but for the most part they are aligned with and in target with the building and construction industries.

We believe both of these have merit. Safety is an issue that is always in tension with economics. There is no getting out of that. We need the independence of both advocates and both agencies concerned with both the economics as well as the safety to have equal footing and an equal platform on which to argue the necessity of their issues.

We believe that any merging of these two would erode the ability to make sound safety decisions in an economic environment, and we believe that they should have equal footing and not be merged and that they both should be funded at adequate levels.

Thank you.

[The prepared statement of Mr. McGarry follows:]

STATE OF NEW YORK
DEPARTMENT OF STATE
ALBANY, N.Y. 12231-0001

GAIL S. SHAFFER
SECRETARY OF STATE

TESTIMONY BEFORE SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

MARCH 23, 1989

BY:

FRANCIS A. MCGARRY
NEW YORK STATE FIRE ADMINISTRATOR

Mr. Chairman, and Members of the Committee, my name is Francis A. McGarry. I am State Fire Administrator for New York State. The position of State Fire Administrator in New York is comparable to the position of State Fire Marshal in several other states; in addition, it incorporates the functions and duties of the State's Fire Training Director. Thus, in New York, we have a unified organizational structure for fire training, fire-fighter certification, investigations, technical assistance, fire reporting, as well as fire research.

My reason for testifying today is to comment on the proposed budget for the Center for Fire Research of the National Institute for Standards and Technology. In addition, I will raise other items relating to the Center's role in the fire protection efforts of the nation.

I will purposefully refrain from sanctifying any arguments for increased attention to fire protection by referring to the horrendous statistics of death and suffering. This tactic has time and again failed to move but a few sensitive decisionmakers; but even worse, it fails to move the general public. These statistics are nonetheless real, but incredibly accepted as the norm. I will attempt, therefore, to focus on systemic and economic arguments in the hope that eventually the toll of human tragedy can be reduced.

You may already know that New York State, under the leadership of Governor Mario M. Cuomo and Secretary of State Gail S. Shaffer, was the first State in the nation to take specific action with respect to the problem of fire gas toxicity. The fire services of New York, and elsewhere for some time recognized the toxic potency of a fire's off-gases. Work conducted, as well as supported by the Center for Fire Research in measuring the toxic potency of fire gases became an essential element in New York's efforts.

Today, New York State requires that certain building materials be tested according to a methodology developed with the support of the Center for Fire Research. Called the University of Pittsburgh Protocol, it provides an indication of a building material's toxic potency. This indication, along with other essential data elements, must be filed as part of a public record in New York before that building material can be used in any structures governed by our State Uniform Fire Prevention and Building Code. By making the information public, it's expected that appropriate professional choices can be made easier.

My point is not to underscore the Center's need to continue their efforts to understand the toxic nature of fire, although I believe it is a pressing concern; but rather that New York, in order to strengthen its fire protection policies, utilized the scientific work generated by the Center as the basis of its efforts. Without the continuing efforts of the Center for Fire Research, New York, as well as other States will be unable to make significant progress in addressing present fire protection concerns.

Few states have the ability or the additional resources to undertake the critical work of fire research. In the past, when limited resources were available, states could turn to the universities and colleges in their search to provide scientific underpinnings for their legislative efforts to improve the quality of life of their citizens. But times have changed and this is no longer feasible! A quick review of the fire research projects being conducted by academia indicates a major portion, if not the entire but limited academic

effort nationally, is being underwritten through cooperative funding arrangements with the nation's industrial giants.

This also holds true for private researchers. Unfortunately, these are the same industries that government may need to control in its effort to improve the quality of life. Looking toward universities and colleges for the scientific justification for its regulatory efforts, government as well as the schools face a critical dilemma: namely, the universities and colleges must face, if not a conflict of interest, at least a conflict of commitment!.... And government must ask the question: "What degree of freedom can one expect from college and university researchers, whose livelihood is dependent on continued industry funding, when government insists on research projects that may be ultimately used to regulate the very industries on which the researchers depend?"

Government has nowhere to turn for uncompromised scientific and engineering support....except to itself! Logically, the only efficient and coordinated way in which this vital research can be conducted is at the Federal level, through an uncompromised governmental entity, supported by government funds. The Center for Fire Research can fulfill this vital purpose. It would be ridiculous to have 50 states working on the same problem with 50 different projects. The coordination would be impossible....and its absence would be a scandalous misuse of our scarce public resources. We have no place to turn, except to the Center for Fire Research.

My second concern addresses the continuing need to adequately fund fire research; not at the levels that have been provided in recent years, but at levels more commensurate with the fire problem. It is not that fire professionals are ungrateful for past appropriations which Congress has graciously provided over the previous Administration's objections. But the fire problem is as enormous as it is complex.

In New York during 1987, fire destroyed property valued at 1.7 billion dollars. Without considering the indirect costs, which are normally four times the direct loss, the enormity of the problem becomes clearer when we consider that New York is but one of fifty states. Considering that New York proportionately represents approximately 10 percent of the nation's characteristics (and I believe this may be conservative), thus, the nation suffers a real property loss of close to 17 billion dollars per year.

Add to this the indirect costs, and we are looking at a 68 billion dollar annual loss. THUS, WE ARE FORCED TO SPEND APPROXIMATELY 68 BILLION DOLLARS OF NEW WEALTH EVERY SINGLE YEAR TO REPLACE THE WEALTH LOST FROM THE YEAR BEFORE! 68 BILLION DOLLARS IS AN OUTRAGEOUS PRICE TO PAY....JUST TO STAY EVEN!.... AND THIS DOESN'T EVEN CONSIDER THE ADDITIONAL COST OF HUMAN SUFFERING OR RELATED HEALTH CARE. Ironically, while we face an affordable housing shortage in this country, we continue to allow fire to destroy substantial portions of our existing housing every year!

Fire protection today suffers from a lack of scientific knowledge and understanding. Very little, in terms of new technology, has been applied to the fire protection problem....very little, relatively speaking, has been added until recently to our scientific understanding of fire. What is needed, not only from the economic perspective, but also from the human and social

perspective, is a better understanding of the destructive potential of fire. The scientific and engineering knowledge of how fire behaves has yet to be expressed in terms clear enough to bring about the necessary innovative changes in engineering, technology and behavior which are needed to reduce the tragic instances of fire. As an example, we may know that fire kills....but we still don't know "WHAT IT IS" that precisely does the killing. (Smoke inhalation is one of our most artful, but scientifically empty diagnostic terms).

We also know that in many instances fire burns ferociously and spreads rapidly, but we don't know enough of the "why" to prevent our building materials and building contents from being major contributors to the process.

State and local fire officials responsible for code enforcement are continually barraged by clever marketing specialists with innovative engineering ideas and new poducts claiming to reduce the fire potential. Lacking a sound basis of scientific and engineering understanding, and having inexact methods of measuring concept and product performance, we are forced to evaluate the effectiveness of the ideas and products against the limited bounds of experience. Lacking experience, we are sometimes forced to accept defective concepts until experience proves them flawed. In this case, experience is far from the "best teacher"--it's expensive and very deadly.

What the fire service experiences, and what engineers and manufacturers claim for their various ideas and products is, if not contradictory, at least widely divergent. This is precisely why we need the scientific and engineering investment to understand how materials and products react in a fire. Without this critical knowledge, we will continue to apply defective engineering concepts and defective technology in our stumbling efforts to halt this massive waste of resources. Having experience as our only guide is literally "killing us" as we continue to test building and engineering safety concepts and in real life situations. We as a nation have been "penny wise and pound foolish". I came here today to ask you to invest our resources wisely. I ask you to invest a miniscule percentage of the amount we destroy in this country every year to advance the scientific understanding of the fire problem.

I am firmly convinced that the return on investment, both in human lives and suffering, as well as real property savings, will be greater than any blue chip stock on today's market.

New York, as well as other states, have used knowledge that the Center for Fire Research has both developed, and generated through its grant programs. I urge you to provide at least 10 million dollars this and every year to continue this work; and help us, the fire officials of each State, control the massive fire problem. Ten million dollars represents about .015 percent of the amount fire will destroy this year.

But armed with the understanding and scientific knowledge for developing proper strategies, we can make great progress! State fire officials accept the fact that fire protection is a state and/or local responsibility, and we are willing to assume this responsibility....but we cannot do it without your help!

We cannot turn to the colleges and universities of this country to provide what we need--they are already committed. We can't turn to the private researchers....they too are committed. WE CAN ONLY TURN TO YOU!

Finally, with respect to the Administration's proposal to recombine the Center for Fire Research with the Center for Building Technology, I would suggest to you that this action is not only without merit, but is extremely dangerous. The Center for Building Technology has its unique purpose and I believe that purpose has merit. But fire protection traditionally is not, nor will it ever be, a significant concern of the Center for Building Technology. Without the single minded purpose of the Center for Fire Research, our national focus and commitment to control fire would be dangerously vulnerable.

In addition, the Center for Fire Research's communication links and program/goal input should come from the community of fire protection professionals. Thus, the Center should be more intimately linked to the programs and goals of the U.S. Fire Administration and the National Fire Academy, not the building and construction industries. Combining it with the Center for Building Technology simply reduces, if not completely cuts off this vital communication link to the fire professionals. Any watering down of the Center's single minded focus would dangerously erode our potential to reduce fire in this nation.

In conclusion, I have included in my written submission a description of the existing programs which I believe the Center needs to pursue with deliberate speed. I have also listed the projects which I believe the Center should immediately initiate or intensify and expand: these are the projects for which the additional funding is critically needed and requested.

I am available for any questions you may have regarding my testimony.

ATTACHMENT A

**CENTER FOR FIRE RESEARCH**
**NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY**

**BUDGET HISTORY AND STATUS**

The appropriated budget for the CFR was $5.7 M in FY-81. It rose to $6.1 M in FY-85 and then declined to $5.6 M in FY-88. The budget increased to $5.7 M in FY-89 with a one-time increase for work on furniture fire tests. These amounts include adjustments to base, Gramm/Rudman/Hollings reductions, and the $500 K reduction due to the "deal" between the Congress and OMB in FY-87. The "other agency" funds needed to maintain the same approximate level of effort (staff) rose from $2.0 M in FY-85 to $3.9 M in FY-89. (Other agency funds are those funds paid into CFR by others to perform specific research tasks. Included in this category, in addition to funds from other government agencies, are funds from the private sector which have remained below $500 K despite considerable effort by CFR management to increase.)

The impact on the CFR staff and technical programs due to continued budget uncertainty and the increased dependance on other agency funds has been profound. First, CFR has lost 30% of its "movers and shakers" over this period. (This estimate is derived from counting project leaders in the staff in FY-81 and again in FY-88.) The full-time permanent staff has declined from 98 in FY-80 to 78 in FY-89. After funds are taken off the top for the grants program, computer support, etc., appropriated funds provide less than 50% of the total support for bench-level scientists. This dependance on other agency funds has led to over 60% of the project leaders, CFR's "best" staff, working on problem solving for other agencies rather than on the planned research programs of the CFR.

The CFR grants program has been reduced by $500 K. Travel and training have been significantly reduced to cut costs.

As of March 1, 1989, CFR has a cash in hand deficit of over $1 M for FY-89, the year ending September 30, 1989. This is with a total operating budget of about $9 M. Chances are fairly good for acquiring the needed funds, however, a very large portion of managers and project leaders time is devoted to fund raising. Cash flow problems have led to many project/staff reassignments within the Center with the longer term projects that support the CFR goals suffering the most.

ATTACHMENT B

**THINGS THAT CFR IS NOT WORKING ON OR IS WORKING ON WITH SUB-CRITICAL EFFORT BECAUSE OF LACK OF FUNDS**

1. Toxicity Performance Test Method

   The effort that will ultimately lead to a widely acceptable toxicity performance test method that produces data that is useful in fire hazard and risk models is sub-optimum. The full-scale fire experiments that are necessary to assure that small-scale tests are providing valid data, are not being conducted.

2. Leadership Role in Technology for Fire Standards

   CFR currently has no leadership role in either national or international fire standards. CFR does participate as "another member of the committee". Active leadership on the part of CFR in international standards would lead to more acceptance of U.S. standards in the international community. Real technical support of standards activities would move both national and international standards to a sound technical base much faster.

3. Fire Investigation

   CFR has undertaken a minor role in fire investigations that includes investigating one or two fires a year and doing some limited analyses. More complete, in-depth analyses along with small scale materials tests and large scale verification tests are needed to develop the information needed by the fire community and the "lessons to be learned". In addition, the fire community needs a national resource that they can go to for advice, analyses, tests, etc. to assist local efforts in fire investigation.

4. Fire Initiation Model

   Information about the ignition process, both behavioral and physical, is lacking. No on-going effort is designed to address this problem. Good prediction capabilities for fire risk cannot proceed without this important piece.

5. National Fire Database

   Two kinds of data bases are needed. A data base of materials and products fire properties data to be used as input to the models of fire growth and spread, fire hazard and fire risk. A second data base of fire test data is needed to assist in model verification, input to models, etc.

6. Technology Transfer and Fire Safety Education

There is a need for a technology clearing house in the fire community to gather existing technology, modify or otherwise package it to address specific needs, develop training in the use of technology, and effectively move the technology into the hands of those who need it. Development of fire safety education materials needs to be a part of this effort. There is a minimal effort to transfer CFR developed technology to the fire safety community.

7. Leadership Role in Fire Codes

Several years ago, CFR dropped out of active participation in the development of model codes because of the lack of funds. No other organization has adequately filled the need for objective scientific support for the code making process. Technical issues are often resolved without good technical information and understanding.

8. Expert Systems

The use of expert systems to answer fire safety questions by calling up the appropriate analytical tool, models, data, etc. and providing answers in understandable terms is clearly the need of the fire community of the future. There is no effort in the fire community to develop appropriate expert systems for this purpose.

9. Fire Hazard Assessment

HAZARD I has demonstrated the potential for a comprehensive fire hazard assessment method. Improving the method, expanding the applications, verification testing, etc. are all moving very slowly.

10. Fire Risk Assessment

Competences must be developed and/or acquired that have the ability to systematically approach the problem of developing fire risk assessment methods. Efforts to date show the need for such competencies and for the development of good fire risk assessment methods.

11. Advanced Suppression and Detection Technologies

The need for, and use of, advanced suppression and detection technologies needs to be demonstrated. (Seems obvious and in some cases it is.) One need/use for advanced detection technologies is to provide input data to the fire growth and spread models that the fire suppression force will have to guide their fire fighting and smoke control efforts. Another need is to provide accurate advanced warning and coupled advanced suppression that extinguishes fires when they are very small. The technology needs to be advanced.

12. Technologies for the Mitigation of the Fire Hazards of Building Materials and Furnishings

Congress appropriated a one-year, FY-89, increase in funds to begin the development of test methods suitable for measuring the fire performance of upholstered furniture. This effort needs to be continued and expanded.

ATTACHMENT C

**RECENT ACCOMPLISHMENTS**
**CENTER FOR FIRE RESEARCH**

The Center for Fire Research at the National Institute of Standards and Technology (formerly the National Bureau of Standards) provides the focal point for the Nation's research related to fire. Examples of the Center's recent accomplishments are:

Fire Investigation - Demonstrated the use and value of CFR developed analytical and predictive methods in the investigation and reconstruction of major fires, the Dupont Plaza Hotel fire in Puerto Rico and the First Interstate Bank building in Los Angeles.

Fire and Smoke Hazard Assessment - The first example of a comprehensive fire and smoke hazard assessment method, HAZARD I, was developed. The method was evaluated in a field test involving almost 100 participants from the international fire safety community and was improved in response to comments. The general release version will be available by mid 1989. Hazard I calculates the hazard to people due to a fire in a building.

Gas and Oil Well Blowout Fires - CFR developed the technology for extinguishing or controlling well blowout fires with relatively small water sprays. The technique was demonstrated in full scale tests. This water spray technique was very effective on unobstructed fires and provides the potential for major cost savings over other approaches.

Wood Stove Fire Hazard Model - Hundreds of CFR experiments in recent years have led to major revisions to the installation criteria and codes for solid fuel burning appliances resulting in major reductions in fire losses due to improper installation. CFR has now used that data to create a general purpose model for predicting the heat transfer from solid fuel burning stoves to combustible surfaces that permits the user to determine if an ignition hazard exists.

Nuclear Winter Calculations - CFR made detailed measurements of fire energy release rates, and near to the fire plume temperatures, velocities and soot concentrations. These measurements are the basis for the fire source terms used in the CFR calculations of multiple fire effects characterizing the aftermath of thermonuclear war. The calculations are extensions of the field modeling techniques originally designed to predict fire driven flows in rooms.

Flame Spread Test - A CFR developed lateral flame spread and ignition measuring apparatus (LIFT) has been proposed by the International Maritime Organization (IMO) as the standard method for evaluating materials used in ocean going vessels. The method is also under consideration by both ASTM and ISO.

Diffusion Flame Profiles - CFR fundamental research now clearly identifies the region in methane/air diffusion flames where the earliest particles are formed that control the amount of soot generated in the flame. This knowledge is a building block necessary for developing the ability to predict soot generation and to design less sooty materials.

Breathing Apparatus Fit Test - CFR developed a low cost, quantitative, respirator fit test apparatus based on a light-scattering smoke detector for the sensing element. This apparatus will meet the need for a low cost, easy to use instrument for monitoring a respirator's fit to a worker's face, such as a fire fighter's breathing apparatus.

Dyed Salt Water Smoke Simulation - CFR has demonstrated and is using a technique to simulate smoke flow through complex structures using dyed salt water in a scale model filled with fresh water. The dyed salt water-fresh water buoyant flow technique is particularly useful for structures that are too complex for the current computer fire flow models.

FIREDOC - The Center's computerized bibliographic database on fire research, FIREDOC, has been made available for searching via telephone using a computer and a modem. Approximately 15000 of the Center's collection of over 30,000 fire research reports and papers are currently available in the system.

Fire Simulation Laboratory - CFR established a Fire Simulation Laboratory as a means for transferring analytical fire safety tools to the practicing fire protection community. All of the CFR developed fire and smoke models as well as others are available in the laboratory.

Computer Bulletin Board - CFR has established a public access computer bulletin board featuring computer programs developed by the Center. The bulletin board also has information on FIREDOC, the CFR computerized bibliographic system, and Center for Fire Research activities.

Human Behavior in Fire - CFR developed a computer model called EXITT that simulates the actions and movement of individuals in a fire situation. The model is based on interviews with fire survivors and on psychological rules for behavior. EXITT predicts the location and activity of each individual in a building during a fire until they are finally overcome by the fire or they escape. EXITT is a module in HAZARD I.

Cigarette Safety - CFR completed a comprehensive study of cigarette characteristics affecting the liklihood of other materials being ignited from a dropped cigarette. The study produced information needed to develop cigarettes that are more fire safe and to develop a measurement method.

Mr. BROWN. Thank you, Mr. McGarry.
Now, let's see if Mr. Connolly has any arguments with you.

## STATEMENT OF WILLIAM M. CONNOLLY, DEPARTMENT OF COMMUNITY AFFAIRS, TRENTON, NJ

Mr. CONNOLLY. I am afraid not.

I want to thank you very much for having us here today. I come to speak here on behalf of our state governments.

I would like to say it is good to be here again, but we, like you, are beginning to get a little bit worn by the annual parade each year for the last dozen, half dozen, state building regulatory officials have come here to endorse the continued support of the Center for Building Technology and the Center for Fire Research.

It has been good in the sense that this subcommittee understands and has restored funds. You have been a friend, and we appreciate that very much.

You have my written statement, and I am not going to repeat it at all. What I would like to do, rather, is just take a couple of minutes and share some of our broader concerns.

We took a great deal of heart when the Congress took action recreating the Bureau of Standards as the National Institute of Standards and Technology. It was an important step, but the budget before you fails to support that step.

We have a serious competitiveness problem in the construction industry. Construction is 9 percent of the Gross National Product in America, and by and large it is still made in America. But for how much longer?

We might be inclined to think that is not a problem, but those that think it isn't a problem should recall perhaps, as I do, the first time I saw a Toyota. For me it was in the summer of 1971. It was the silliest idea I ever thought of at the time. It is not funny any more.

Construction in New Jersey—in the United States—I am sorry—is an incredibly disaggregated operation. Our building regulatory system and our standards systems are in large measure responsible for the fact that innovation comes very hard in the United States of America. Potentially, you need as many as 28,000 approvals for one new product in this country.

Under the Constitution, we in the states are fundamentally responsible for the building regulatory system. In the last 10 years or so, we have begun to make a lot of progress in terms of preemptive state building codes and state activity in the building regulatory system.

But we need a federal partner. The National Institute of Standards and Technology should be that partner, could be that partner, but it hasn't been able to.

They have done valuable work in important aspects of energy conservation, structural performance, and fire behavior.

We in the states believe the nation needs a greatly strengthened research and development activity to support the restructuring of our product approval system so that our immense domestic market can be an asset and not a drag, as it presently is, to our domestic

producers. We need this, but we have been frankly going in the other direction.

The decade long struggle to preserve the funding of these important research activities, struggle by this committee, has resulted in fact in a 50 percent real reduction in capability across that decade.

There is a federal role in this area. The states cannot do it. It would be wasteful, it would be duplicative, and, more importantly, the states and local governments already make a very heavy investment in the delivery system, our building regulatory activities.

In New Jersey alone we spent $15 million a year at the state level, another $24 million at the local level in these kinds of activities, $39 million in New Jersey alone compared to a suggested federal investment in the same kind of activity of $5 million in this year's budget. I think something is sadly out of whack.

The private sector cannot do it. As other witnesses have mentioned, only product manufacturers have the scale and the scope, and they are concerned with individual products, and there is no way to integrate the outcome of that research into something that is systemwide.

Let me just mention quickly a couple of examples of the kinds of problems we face where we ought to be able to get some help and we just can't.

Right now at the state level I am dealing with a pretty earthy subject, the 1.6 gallon water closet. Should we accept it, should we approve it, what is the impact of it on plumbing systems design and things like that?

Where do I go for research support? Where do I go for the information that will let me responsibly approve an innovation which would have a tremendous impact in terms of water conservation in our area?

I will tell you where I am going. I am going to the same place the product ideas came, Europe.

National pride quite aside, to have to go to Europe for research in that kind of an activity illustrates the kind of problems we have in the United States of America in introducing innovations.

Another one is the problem with flame retardant treated plywood. Our sad lack of a comprehensive and integrated product approval system has permitted a product to come onto the market that apparently, at least in some cases, has no durability at all when used in roof systems. It is going to cost the building community in New Jersey probably $90 million and the state government $40 million to rip that stuff out and replace it with material that has some durability in the roofs of many homes across the State of New Jersey.

If we had a better system for the introduction of innovations and new technology in the construction community, the regulatory system itself would not have to be so conservative. If we had a research base which we could rely upon, we wouldn't have to be creating the problems that we are.

There are a whole host of areas where the National Institute of Standards and Technology should be of help, could be of help, would like to be of help, but simply is not going to be with the current funding levels—indoor air quality, innovative plumbing equip-

ment, durability standards, integrated automation in buildings, fire toxicity, fire behavior. The list could go on and on.

You can't do a whole lot with $5 million in those areas.

Without a sound, technological basis for accepting innovations, we in the regulatory system have no other alternative than to choke off innovation, but it won't be choked off everywhere. It will arrive full-blown from Japan and from Europe, where they don't have these kinds of problems, and we will no longer be able to laugh at the idea of buildings made in Japan.

All of us in the Northeast have seen this steady parade of product manufacturers and industrialized construction organizations from the Scandinavian countries and from Japan. They are coming. There is no doubt about it. Our domestic industry is not at the present time able to compete for the kinds of reasons that I have suggested.

There is another road. The Congress has seen it and has created the institutions, the National Institute of Standards and Technology, where we can undertake the basic standards and integrated research activity that we need to support a reasonable system, and the National Institute of Building Sciences, where we can create an institutional structure for cooperation and market aggregation and product approval.

They have not nearly been able to fulfill their promise, for different reasons. These are hard budgetary times. You don't need me to tell you that. But even in hard times investment in the future has to take a priority, investment to preserve and enhance the economic activity in this country which makes everything else possible.

We need to do a lot more than restore $3.9 million to the proposed budget. We need to fund a serious competitiveness effort to remove barriers in the construction industry related to international standards activity and related to our domestic product acceptance system.

If you restored $3.9 million and added another $5 million to address the competitiveness issue in the construction industry, you would still be spending at the federal level less than one-third of what one state spends on the building regulatory system.

If the national government can't do this, then no one will, and it will go undone. The states can and will do their part, but we need a strengthened National Institute of Standards and Technology and a reinvigorated National Institute of Building Sciences to work with.

Thank you very much.

[The prepared statement of Mr. Connolly follows:]

# A SUMMARY OF THE WRITTEN TESTIMONY

# OF THE

# NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC.

Before The:

U.S. House of Representatives
Subcommittee on Science, Research, and Technology

In the Matter Of:

Fiscal Year 1990 Budget Proposal Funding
for the National Institute of Standards
and Technology Center for Fire Research
and Center for Building Technology

By:

William M. Connolly, AIA
Director, Department of Community Affairs
State of New Jersey
Past President, NCSBCS

Date:

March 23, 1989

A Summary of the Written Testimony

of the

National Conference of States on Building Codes and Standards, Inc.

Regarding the proposed fiscal year 1990 funding for the National Institute of Standards and Technology Center for Building Technology and Center for Fire Research at $4 million less than their fiscal year 1989 funding levels, the National Conference of States on Building Codes and Standards, Inc. (NCSBCS) offers the following findings:

1. The National Institute for Standards and Technology Center for Building Technology and Center for Fire Research continue to provide the nation's states and local governments with irreplaceable building and technological research. The states and local governments continue to depend upon the Institute's expertise to help them adopt and enforce modern building and fire codes which provide for their public's health and life safety in new and existing buildings.

2. The Center for Building Technology and Center for Fire Research have undertaken irreplaceable national research in the areas of indoor air quality, building energy conservation, building seismic and structural safety, and fire safety. This research must be allowed to continue at previously funded levels in order to provide the nation's public with adequate health and life safety in buildings.

3. The states, individually or working together, cannot and will not be able to build, staff, and fund or contract for such research should the Center for Building Technology and Center for Fire Research be reduced in their current operating budgets or should they even cease to operate.

4. If the states were able to build, staff, and fund or contract for such research, inconsistencies in the research programs between the states in the area of building and fire safety would result in redundancy and in an inexcusable waste of the taypayers' funds.

5. America is facing a growing crisis in its ability to retain and enhance its competitive position in the world economic community. To do so will take a redoubling of our nation's commitment to research and development and to technology transfer. The National Institute of Standards and Technology Center for Building Technology and Center for Fire Research have key roles to play in that process.

Based upon these findings, NCSBCS concludes that in these times of continued federal budget reduction and the growing U.S. trade deficit, the centralization of research in building technology and fire safety at the federal level has become an even more vital and fiscally responsible role for the federal government. The National Institute of Standards and Technology Center for Building Technology and Center for Fire Research, at a minimum, should continue to be funded as they have been in the past, and that plans should be made to consider a more adequate funding of these two centers in order for them to carry out their new and vital technology transfer role in the future.

# WRITTEN TESTIMONY OF THE NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC.

BEFORE THE:

U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON SCIENCE, RESEARCH, AND TECHNOLOGY

IN THE MATTER OF:

FISCAL YEAR 1990 BUDGET PROPOSAL FUNDING
FOR THE NATIONAL INSTITUTE OF STANDARDS
AND TECHNOLOGY CENTER FOR FIRE RESEARCH
AND CENTER FOR BUILDING TECHNOLOGY

BY:

WILLIAM M. CONNOLLY, AIA
DIRECTOR, DEPARTMENT OF COMMUNITY AFFAIRS
STATE OF NEW JERSEY
PAST PRESIDENT, NCSBCS

DATE:

MARCH 23, 1989

# WRITTEN TESTIMONY OF THE NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC.

I AM WILLIAM CONNOLLY, DIRECTOR OF THE DEPARTMENT OF COMMUNITY AFFAIRS FOR THE STATE OF NEW JERSEY, AND GOVERNOR THOMAS KEAN'S DELEGATE TO THE NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC. (NCSBCS).

SINCE ITS FOUNDING BY THE NATION'S GOVERNORS 22 YEARS AGO, NCSBCS HAS WORKED COOPERATIVELY WITH FEDERAL AGENCIES AND PUBLIC AND PRIVATE SECTOR ORGANIZATIONS TO HELP THE STATES BETTER SERVE THEIR CITIZEN'S HEALTH AND LIFE SAFETY INTERESTS IN BUILDINGS. AS A PAST PRESIDENT OF NCSBCS AND AS A REGULATORY OFFICIAL FOR THE STATE OF NEW JERSEY, I APPEAR HERE TODAY TO URGE THE U.S. CONGRESS TO CONTINUE IN THE 1990 FISCAL YEAR BUDGET TO PROVIDE ADEQUATE FUNDING FOR TWO OF THE MOST IMPORTANT NATIONAL RESEARCH FACILITIES IN OUR NATION---THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY CENTER FOR BUILDING TECHNOLOGY (CBT) AND CENTER FOR FIRE RESEARCH (CFR).

NCSBCS IS COMPRISED OF A GOVERNOR-APPOINTED DELEGATE FROM EACH OF THE 50 STATES AND SEVERAL TERRITORIES, AND HAS SEVERAL KEY AGREEMENTS WITH OTHER ORGANIZATIONS WHICH HELP NCSBCS FULFILL ITS TASK OF REPRESENTING STATE GOVERNMENT INTERESTS IN BUILDING CODES AND PUBLIC SAFETY. AMONG THESE AGREEMENTS ARE AN EXECUTIVE BRANCH AGREEMENT WITH THE NATIONAL GOVERNORS' ASSOCIATION, THROUGH WHICH NCSBCS PROVIDES DIRECT TECHNICAL

SUPPORT ON BUILDING CODES AND STANDARDS ISSUES, AND A MEMORANDUM OF UNDERSTANDING WITH THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY THROUGH WHICH THE STATES RECEIVE INVALUABLE RESEARCH AND TECHNICAL DATA RELEVANT TO PUBLIC SAFETY IN THE BUILT ENVIRONMENT FROM THE CENTER FOR BUILDING TECHNOLOGY AND CENTER FOR FIRE RESEARCH.

OVER THE PAST SEVEN YEARS, NCSBCS HAS EITHER APPEARED BEFORE OR PROVIDED WRITTEN TESTIMONY TO SUBCOMMITTEES OF THE HOUSE AND SENATE IN SUPPORT OF CONTINUED FUNDING FOR THE CBT AND THE CFR. BELOW IS A LIST OF TECHNICAL SERVICES WHICH THESE TWO CENTERS HAVE PROVIDED TO THE STATES--SERVICES UNOBTAINABLE ELSEWHERE IN OUR NATION.

1. CONTINUED RESEARCH ON ENERGY CONSERVATION IN NEW BUILDINGS WHICH HAS RESULTED IN THE DEVELOPMENT OF THE AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC. (ASHRAE) STANDARD 90, "ENERGY CONSERVATION IN NEW BUILDINGS." THIS IS THE CURRENT TECHNICAL BASIS FOR THE ENERGY CODES IN THIS COUNTRY. EACH YEAR, THESE CODES SAVE THE AMERICAN PUBLIC MILLIONS OF DOLLARS IN FUEL COSTS.

2. RESEARCH TO DEVELOP COST-EFFECTIVE GUIDELINES FOR BUILDING REHABILITATION AND, MORE RECENTLY, METHODS FOR CONDITIONAL ASSESSMENT OF EXISTING BUILDINGS WHICH HAVE BEEN PROCESSED AS A NATIONAL STANDARD BY THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

3. RESEARCH IN AUTOMATIC SPRINKLER TECHNOLOGY, FLAMMABILITY OF MATERIALS, AND FIRE MODELING USING COMPUTER TECHNOLOGY. THIS RESEARCH HAS RESULTED IN NEW CODES AND STANDARDS AND HAS SAVED COUNTLESS LIVES.

4. RESEARCH INTO THE DURABILITY OF MANUFACTURED HOUSING WHICH HELPED THE U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD) FORMULATE ITS NATIONAL MANUFACTURED HOUSING CONSTRUCTION AND SAFETY STANDARDS PROGRAM.

5. IN THE EARLY 1980S, RESEARCH INTO BUILDING SEISMIC SAFETY DESIGN. THROUGH THE FOLLOW-UP WORK OF THE BUILDING SEISMIC SAFETY COUNCIL, THIS RESEARCH IS NOW BEING INCORPORATED INTO NEW BUILDING CONSTRUCTION THROUGHOUT THIS COUNTRY.

6. RESEARCH INTO THE NEEDS FOR "STANDARDS FOR BUILDING MATERIALS, EQUIPMENT, AND SYSTEMS USED IN DETENTION AND CORRECTIONAL FACILITIES," WHICH IS LEADING TO THE DEVELOPMENT OF NEEDED PERFORMANCE CRITERIA FOR THESE TYPES OF BUILDINGS.

7. RESEARCH INTO FORMALDEHYDE OFF-GASING, INDOOR AIR QUALITY, FIRE AND SMOKE TOXICITY OF BUILDING MATERIALS, AND SMOKE MOVEMENT CHARACTERISTICS IN TALL BUILDINGS. THIS HAS BEGUN TO MAKE IMPROVEMENTS IN BUILDING AND FIRE CODES AND STANDARDS, THEREBY REDUCING THE HEALTH AND LIFE SAFETY HAZARDS TO THE AMERICAN PUBLIC.

OVER THE PAST FIVE YEARS, NCSBCS HAS SURVEYED THE STATE GOVERNMENT INTERESTS AND HAS REPORTED IN TESTIMONY BEFORE THIS COMMITTEE AND TO YOUR COUNTERPART IN THE SENATE THAT IF FUNDING FOR THE CBT AND THE CFR WAS EXTREMELY REDUCED, THE STATES THEMSELVES, ACTING ON THEIR OWN, COLLECTIVELY, OR WITH THE COMBINED RESOURCES OF THE PRIVATE SECTOR, COULD NOT EVEN BEGIN TO DUPLICATE, LET ALONE REPLACE, THE STAFF AND FACILITIES OF THESE TWO CENTERS. IN AN NCSBCS SURVEY CONDUCTED LAST MONTH, THE STATES OVERWHELMINGLY AGREED THAT THE INSTITUTE REMAINS THE SINGLE SOURCE THROUGH WHICH VITAL BUILDING AND FIRE SAFELY RESEARCH CAN BE NATIONALLY COORDINATED. AMONG THE COMMENTS RECEIVED FROM THE STATES WERE AS FOLLOWS:

- STATE OF INDIANA: "IF THESE TWO CENTERS WERE NOT ADEQUATELY FUNDED, THEN A VALUABLE ASSET WOULD BE LOST TO THE BUILDING SCIENCE COMMUNITY. WE SEE LITTLE HOPE FOR PRIVATE INDUSTRY PERFORMING SUCH BASIC RESEARCH, ONLY APPLICATION OR MARKETING RESEARCH."

- STATE OF MARYLAND: "REFLECTING UPON THE FACT THAT MOST STATES HAVE ALMOST EXACTLY THE SAME BASIC RESEARCH NEEDS, THE TWO CENTERS ARE, AND WILL CONTINUE TO BE, AN IMPORTANT CONDUIT TO SOLVING AND IMPROVING STATE TECHNOLOGY AND RESEARCH NEEDS."

- STATE OF LOUISIANA: "CONGRESS HAS A RESPONSIBILITY TO ITS CITIZENS OTHER THAN TO GENERATE FEDERAL REVENUES (AND NATIONAL DEFENSE). EVEN WITH LOOMING DEFICITS,



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CONGRESS STILL HAS A RESPONSIBILITY TO PROTECT ITS CITIZENS. IF THE UNITED STATES DOES NOT KEEP UP WITH NEW TECHNOLOGIES AND CONTINUE WITH FIRE AND BUILDING TECHNOLOGY RESEARCH, THE CITIZENS WILL INEVITABLY BE AT RISK. NEW TECHNOLOGIES AND PRODUCTS WILL MAKE THEIR WAY INTO THE MARKETPLACE WITHOUT PROPER ANALYSIS AND EVALUATION."

DESPITE CALLS BY SOME IN RECENT YEARS TO PROVIDE NO FUNDING FOR THE CBT AND THE CFR, THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY HAS BEEN ABLE TO CONTINUE TO CARRY OUT ITS VALUABLE RESEARCH BECAUSE YOU AND YOUR COLLEAGUES IN THE HOUSE AND SENATE HAVE SHARED THE STATES' VIEW THAT THESE TWO CENTERS ARE VITAL TO THE PUBLIC'S SAFETY.

HOWEVER, OVER THE PAST 10 YEARS, FEDERAL BUDGET CONCERNS HAVE RESULTED IN THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY CUTTING THE CBT AND CFR PROFESSIONAL AND ADMINISTRATIVE STAFFS BY 50 PERCENT. THIS AT A TIME WHEN THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY'S RESPONSIBILITIES HAVE GROWN TO INCLUDE MAJOR WORK ON BUILDING SEISMIC SAFETY AND INDOOR AIR QUALITY. IN 1988, CONGRESS FURTHER BROADENED THE INSTITUTE'S RESPONSIBILITY TO INCLUDE A MAJOR EMPHASIS ON THE IMPORTANT ISSUE OF TECHNOLOGY TRANSFER.

WITH THE UNIFICATION OF THE EUROPEAN MARKET IN 1992 AND THE INCREASED EXPORT CAPABILITIES FOR THE PACIFIC RIM NATIONS, AMERICA IS FACING A GROWING CHALLENGE FROM ABROAD TO RETAIN AND

ENHANCE ITS COMPETITIVE POSITION IN BOTH ITS DOMESTIC AND FOREIGN MARKETS. TO SUCCESSFULLY MEET THAT CHALLENGE, IT WILL TAKE A REDOUBLING OF OUR DEDICATION TOWARDS FUNDING BASIC RESEARCH AND DEVELOPMENT AND PROVIDING AN EFFECTIVE MEANS FOR ENCOURAGING TECHNOLOGY TRANSFER.

TO MAKE THE UNITED STATES MORE COMPETITIVE WILL ALSO REQUIRE OUR NATION'S FEDERAL, STATE, AND LOCAL GOVERNMENTS TO FIND WAYS OF ELIMINATING OR REDUCING EXISTING BARRIERS WHICH STAND IN THE WAY OF EFFECTIVE MARKET AGGREGATION WITHIN OUR COUNTRY FOR U.S. DEVELOPED AND PRODUCED PRODUCTS AND TECHNOLOGIES.

UNDER ITS NEW NAME, THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY CBT AND CFR HAVE KEY ROLES TO PLAY IN THIS PROCESS. IN A RECENT LETTER FROM GOVERNOR EDWARD DIPRETE (RI) AND RICHARD CELESTE (OH) TO PRESIDENT BUSH, THE NATIONAL GOVERNORS' ASSOCIATION RECOGNIZED THAT ROLE BY NOTING THAT "AS GOVERNORS, WE ARE PERSONALLY AWARE OF THE KEY RELATIONSHIP THAT EXISTS BETWEEN SCIENCE AND TECHNOLOGIES AND A VIBRANT ECONOMY." GOVERNORS DIPRETE AND CELESTE HAVE CALLED FOR THE "NATIONAL COORDINATION OF STATE AND FEDERAL EFFORTS IN SUPPORT OF BASIC SCIENCE, APPLIED RESEARCH, AND TECHNOLOGIES," AND FOR "NATIONAL INCENTIVES FOR COLLABORATION BETWEEN SMALL BUSINESS AND THE NATIONAL LABORATORIES TO COMMERCIALIZE TECHNOLOGY DURING THE TRANSFER PROCESS. THE DIRECTORS OF THE NATIONAL SCIENCE FOUNDATION AND THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY ARE NOW WORKING DIRECTLY WITH STATE SCIENCE AND

TECHNOLOGY ADVISORS TO BEST COORDINATE OUR ACTIVITIES TOWARDS A COMMON GOAL. WE APPLAUD THIS DEVELOPMENT, AND WE RECOMMEND THAT YOUR SCIENCE ADVISOR NURTURE SUCH COLLABORATION, ENCOURAGING ITS EXTENSION TO OTHER BRANCHES OF GOVERNMENT AS APPROPRIATE."

IT IS WITHIN THE SPIRIT OF FEDERAL AND STATE COOPERATION THAT I WOULD LIKE TO USE THE REMAINDER OF MY TESTIMONY TO DESCRIBE JUST A FEW OF THE VITAL RESEARCH ACTIVITIES WHICH THE CBT AND THE CFR HAVE SCHEDULED FOR 1990. THESE ACTIVITIES ARE OF PARTICULAR IMPORTANCE NOT ONLY TO THE STATE OF NEW JERSEY, BUT TO ALL THE STATES ACROSS OUR NATION.

## CENTER FOR BUILDING TECHNOLOGY PROGRAMS

THE CBT IS CHARGED WITH CONDUCTING RESEARCH TO IMPROVE THE USEFULNESS, SAFETY, AND ECONOMY OF BUILDINGS, AND TO ENHANCE THE INTERNATIONAL COMPETITIVENESS OF U.S. CONSTRUCTION SERVICES, TECHNOLOGIES, AND PRODUCTS.

IN A RECENTLY ADOPTED NATIONAL GOVERNORS' ASSOCIATION COMPREHENSIVE ENERGY POLICY, THE NATION'S GOVERNORS CALLED FOR BOTH "SUSTAINED PUBLIC AND PRIVATE INVESTMENTS IN ENERGY RESEARCH AND DEVELOPMENT" AND FOR FEDERAL AND STATE GOVERNMENTS TO "WORK WITH THE HOUSING AND CONSTRUCTION INDUSTRIES AND OTHER PRIVATE AND PUBLIC ORGANIZATIONS TO PROMOTE IMPROVED BUILDING DESIGN AND CONSTRUCTION TECHNOLOGIES FOR ENERGY EFFICIENT

BUILDINGS AND THE PROTECTION OF INDOOR AIR QUALITY." THAT POLICY WENT ON TO NOTE THAT "ADDITIONAL FEDERAL RESEARCH, DEVELOPMENT, AND TECHNOLOGICAL TRANSFER ACTIVITIES SHOULD INCLUDE SUPPORT FOR RESOURCE ASSESSMENT, APPLIED RESEARCH IN BUILDING SCIENCES, ETC."

IN THIS REGARD, SEVERAL ONGOING CBT PROJECTS OF PARTICULAR IMPORTANCE TO MYSELF AND TO MY COLLEAGUES ARE AS FOLLOWS:

- DETAILED TECHNICAL RESEARCH INTO THE THERMODYNAMIC AND TRANSPORT OF POTENTIAL TOXIC PROPERTIES OF REPLACEMENT REFRIGERANTS FOR THE CURRENT CHLOROFLUOROCARBONS (CFC'S) WHICH ARE HAZARDOUS TO THIS PLANET'S VITAL OZONE LAYER.

- DEVELOPMENT OF A DRAFT TEST STANDARD TEST AND RATING PROCEDURES FOR FILTERS WHICH REMOVE GASEOUS POLLUTANTS FROM AIR SYSTEMS IN COMMERCIAL BUILDINGS.

- DEVELOPMENT OF COMPUTER SIMULATION MODELS FOR PREDICTING INDOOR AIR POLLUTANT ACCUMULATION AND MITIGATION WHICH BUILDING DESIGNERS CAN USE IN THE CONSTRUCTION OF MORE ENERGY EFFICIENT AND INDOOR AIR SAFE BUILDINGS.

- A JOINT PROJECT WITH THE ENVIRONMENTAL PROTECTION AGENCY (EPA), HUD, THE NATIONAL ASSOCIATION OF HOME BUILDERS RESEARCH CENTER, AND SEVERAL STATES (INCLUDING MY OWN) TO DEVELOP AN EFFECTIVE METHODOLOGY FOR TESTING BUILDING SITES FOR RADON POTENTIAL.

- A COOPERATIVE STUDY BETWEEN EPA, ASHRAE, THE NATION'S THREE MODEL CODE GROUPS, AND THE STATES TO MORE FULLY UNDERSTAND THE TECHNICAL INTERRELATIONSHIP INVOLVED AND TO PROPOSE APPROPRIATE CODE CHANGES WHICH ELIMINATE CONFLICTS BETWEEN ENERGY CONSERVATION PROVISIONS IN OUR CODES AND PROVIDE FOR ADEQUATE INDOOR AIR QUALITY. SUCH RESEARCH COULD FIT WELL WITHIN THE PROVISIONS OF THE PROPOSED INDOOR AIR QUALITY ACT OF 1989, WHICH IS BEING INTRODUCED BY SENATOR MITCHELL.

THE SEISMIC AND STRUCTURAL SAFETY OF OUR NATION'S BUILDINGS ARE OF INCREASING IMPORTANCE TO ALL OF US. IMPORTANT ONGOING CBT PROJECTS IN THIS AREA INCLUDE THE FOLLOWING:

- TECHNICAL AND RESEARCH SUPPORT TO THE BUILDING SEISMIC SAFETY COUNCIL IN SUCH AREAS AS THE LOAD-DEFORMATION CHARACTERISTICS OF MECHANICAL ANCHORS IN CONCRETE UNDER COMBINATIONS OF TENSION AND SHEAR.

- PROVIDING ON A COST REIMBURSABLE BASIS ONGOING PROFESSIONAL EXPERTISE TO STATE AND LOCAL GOVERNMENTS TO INVESTIGATE AND DETERMINE THE TECHNICAL CAUSE OF MAJOR STRUCTURE FAILURES OF PUBLIC BUILDINGS.

AFFORDABLE HOUSING AND HOUSING AMERICA'S HOMELESS ARE OF SIGNIFICANT IMPORTANCE TO ALL OF US IN THIS COUNTRY. THE CBT HAS SEVERAL ONGOING RESEARCH PROJECTS IN THIS AREA. THESE

INCLUDE RESEARCH INTO NEW ROOFING SYSTEMS, MOISTURE CONTROL IN BUILDINGS, AND RECOMMENDING METHODS FOR DETECTING AND MEASURING LEAD-BASED PAINT IN RESIDENTIAL STRUCTURES.

OTHER RESEARCH NEEDS IN THIS AREA IDENTIFIED BY THE STATES THROUGH THE RECENT NCSBCS SURVEY INCLUDE THE FOLLOWING:

- WORKING WITH HUD AND THE NATION'S FACTORY AND SITE-BUILT HOUSING INDUSTRIES TO DEVELOP LOW COST, SAFE, TRANSITIONAL, AND PERMANENT HOUSING FOR THE NATION'S HOMELESS.

- WORKING WITH HUD AND THE NATION'S MANUFACTURED HOUSING INDUSTRY TO CONDUCT TECHNICAL RESEARCH LEADING TO UPGRADING SECTIONS OF THE FEDERAL MANUFACTURED HOUSING CONSTRUCTION AND SAFETY STANDARDS TO INCREASE STRUCTURAL INTEGRITY AND REDUCE MOISTURE DAMAGE IN HUD-CODE HOMES.

- WORKING WITH NCSBCS, THE NATION'S HOME BUILDING INDUSTRY, THE MODEL BUILDING AND FIRE CODE ORGANIZATIONS, AND THE BUILDING PRODUCT MANUFACTURERS TO ELIMINATE EXISTING REGULATORY BARRIERS TO THE INTRODUCTION OF SAFE, NEW BUILDING DESIGNS AND CONSTRUCTION TECHNIQUES.

NCSBCS, THE NATIONAL ASSOCIATION OF HOME BUILDERS, AND THE MODEL BUILDING CODE ORGANIZATIONS ARE CURRENTLY INVOLVED IN A COOPERATIVE PROJECT IN THIS AREA, AND NCSBCS BELIEVES THAT THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY IN THE YEAR 1990

COULD PROVIDE VALUABLE TECHNICAL SUPPORT TO THIS PROJECT--SUPPORT WHICH WOULD HELP MAKE AMERICA'S BUILDING PRODUCTS AND SERVICES MUCH MORE COMPETITIVE IN THE WORLD MARKET PLACE.

## Center for Fire Research Programs

Charged with providing our nation with a scientific and technical basis for reducing fire losses and costs for fire protection, the CFR has a number of projects planned which are of major significance to our state fire officials and to the citizens they protect. The CFR's planned work in combustion and flammability, fire modeling, fire toxicity measurement, and fire suppression research all represent research projects which the states have targeted as basic research needs, but do not have themselves either funding or facilities which are adequate to conduct such testing. Of special interest to us in New Jersey are the Institute's work in developing methods to enable practicing fire protection engineers to appraise fire safety of buildings and evaluating the impact of specific design proposals for improving fire safety, in addition to CFR's ongoing work to effectively measure combustion toxicity and/or flammability of various construction and finishing materials.

Another area recently identified by the states for potential research by the Institute involves appropriate testing and evaluation procedures for fire retardant treated roofing materials such as plywood. Accompanying this testimony

IS AN ARTICLE IN OUR NCSBCS NEWSLETTER CONCERNING A MAJOR DETERIORATION PROBLEM WITH SOME TYPES OF FIRE RETARDANT TREATED PLYWOOD USED FOR ROOF SHEATHING IN MULTIFAMILY HOUSING. SEVERAL STATES BELIEVE THAT BOTH THE CFR AND THE CBT COULD HELP DEVELOP APPROPRIATE RESEARCH AND METHODOLOGY FOR TESTING SUCH MATERIALS, AND COULD WORK TOGETHER WITH THE STATES AND THE MODEL BUILDING CODE ORGANIZATIONS TO DEVELOP A "SCREENING MECHANISM" TO HELP US UNDERSTAND THE COST IMPACT OF CODE CHANGES AND ALSO HELP TO REDUCE OR ELIMINATE CHANGES BEING MADE TO OUR MODEL BUILDING AND FIRE CODES WHICH CAUSE THE INTRODUCTION OF SIMILAR PROBLEMS PRODUCTS OR TECHNOLOGIES.

I WANT TO CLOSE MY TESTIMONY BY THANKING THE SUBCOMMITTEE FOR ASKING ME TO OFFER THIS TESTIMONY TODAY. AS CAN BE SEEN BY JUST THE FEW EXAMPLES I HAVE GIVEN, THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY CENTER FOR BUILDING TECHNOLOGY AND CENTER FOR FIRE RESEARCH ARE DEEPLY INVOLVED IN MEANINGFUL RESEARCH. RESEARCH THAT SAVES LIVES AND PROMOTES THE PUBLIC'S HEALTH IN THE BUILDINGS WHICH ALL OF US WORK AND LIVE. NEITHER THE CBT OR THE CFR ARE ENGAGED IN "IVORY TOWER" RESEARCH, NOR ARE THEY CONDUCTING RESEARCH IN AREAS WHERE EITHER PRIVATE RESEARCH OR UNIVERSITY TESTING FACILITIES ARE CAPABLE OF PROVIDING SIMILAR SERVICES.

THE STATES APPRECIATE CONGRESS' CONTINUED SUPPORT FOR THESE TWO VITAL RESEARCH CENTERS. WE ARE CONCERNED, HOWEVER, THAT A SIGNIFICANT NUMBER OF THESE AND OTHER PROJECTS WOULD HAVE TO BE CANCELLED, OR SERIOUSLY REDUCED IN SCOPE, SHOULD THE CBT OR THE

CFR BE SUBJECTED TO THE PROPOSED $4 MILLION CUT IN THEIR FY'90 FUNDING FROM THEIR 1989 LEVEL. IN LIGHT OF THE IMPORTANCE OF THESE PROJECTS TO BOTH OUR PUBLIC'S HEALTH AND LIFE SAFETY AND TO OUR ABILITY TO COMPETE ABROAD WITH AMERICAN BUILDING PRODUCTS AND SERVICES, AS A STATE BUILDING REGULATORY OFFICIAL, I URGE YOU AND YOUR COLLEAGUES NOT ONLY TO CONTINUE TO FUND THE CBT AND THE CFR AT THEIR FY'89 LEVELS, BUT IN THE COMING YEARS, TO INCREASE THE FUNDING AVAILABLE TO THESE TWO CENTERS. NCSBCS FIRMLY BELIEVES THAT FAILURE TO ADEQUATELY FUND THESE CENTERS IS NOT IN THIS NATION'S BEST INTEREST IN EITHER THE SHORT OR THE LONG TERM. AS ONE OF OUR MEMBERS RECENTLY PUT IT, WE EITHER SUPPORT THIS UNIQUE AND VITAL NATIONAL RESOURCE OR WE REDUCE OURSELVES TO THE POSITION OF "EATING OUR SEED CORN" AND RISKING NOT ONLY OUR PUBLIC'S HEALTH AND LIFE SAFETY, BUT OUR NATION'S ECONOMIC FUTURE AS WELL. THANK YOU.

## Modularcompact Drafted

In recent presentations before the Mobile Modular Office Association and the Building Systems Council, Don Reville (AZ), Richard Conrad (CA), and NCSBCS Executive Director Robert Wible briefed representatives of the nation's industrialized and modular building industry.

On January 19, Mr. Wible spoke to the Building Systems Council and Modular Buildings Council members about an interstate compact to regulate modular buildings. A state implementation committee has prepared a first cut of a detailed draft model compact and an outline of companion federal legislation recognizing the compact. These two documents are available to industry by contacting NCSBCS.

The Joint Council on Industrialized/Modular Buildings reviewed the model compact at its February 23-24 meeting in Herndon, Virginia.

On February 8-10, Don Reville and Richard Conrad presented the compact and companion federal legislation to the Board of Directors and members of the Mobile Modular Office Association. They stressed the critical need for the nation's builders of commercial modular structures to become active participants in the current state and industry efforts to develop a uniform national system for the regulation and interstate reciprocity of all types of factory-produced buildings.

NCSBCS cannot emphasize enough the need for all parties to enter into cooperative discussions on the most effective approach towards resolving industry concerns and assuring health and life safety in industrialized/modular buildings.

The compact will be discussed at the NCSBCS Semiannual Meeting April 10-11 in Vienna, Virginia. NCSBCS members will consider changes recommended by the states, manufacturers, third party agencies, and consumer groups. The NCSBCS Implementation Committee will meet April 11 to consider what further action to take on the draft compact and companion federal legislation.

## Conover's code work cited by *ENR*

David R.Conover, Director of Technical Services for NCSBCS, has been cited by *Engineering News Record* as one "who made marks in 1988." Mr. Conover was recognized for his work with Codeworks Corporation in gathering code information for state and local jurisdictions and abstracting it into a computerized data base.

Forty other individuals were recognized for their contributions to the construction industry, including Dennis Brown, Executive Vice President of Product Development and Chairman of the Board of Codeworks Corporation. Others nominated include architect I.M. Pei for his redesigns for the Louvre, craftsman John V. Barianos for his work in restoring Washington D.C.'s Union Station, and Federal District Court Judge Robert C. Zampano who mediated the L'Ambiance Plaza collapse dispute.

One of those individuals has been chosen as ENR's Man of the Year and will be honored at a February 22 dinner in New York City.

Mr. Conover joined NCSBCS in 1980 and is active in ASHRAE, NFPA, and the model code groups.

## Roofing problem illustrates need for code screening mechanism

The National Association of Home Builders (NAHB) has formed a task force to investigate reports of deterioration of some types of fire-retardant treated (FRT) plywood used for roof sheathing.

"The task force will examine the extent of the problem and possible solutions," said Dale Stuard, NAHB Past President. "Specialists from both the NAHB staff and our National Research Center are actively looking into it."

The FRT sheathing is treated by firms which specialize in pressure treating wood products with chemicals. It is commonly used in roof sheathing for townhouses and multifamily apartments to prevent flames from jumping from one unit to another in the event of a fire. In some instances, heat and moisture have contributed to a chemical reaction that can make the plywood become extremely brittle and can cause it to deteriorate. The problem is most likely to be found east of the Mississippi and in some Southwestern states. NAHB is not aware of the problem occurring in single family detached homes.

BOCA has permitted use of FRT plywood for roof sheathing since 1979, SBCCI since 1981, and CABO since 1983. Many state and local building codes permit FRT roof sheathing.

David Hammerman, Director of Codes Administration in the Department of Housing and Community Development for the State of Maryland said, "This is a perfect example of the need to more thoroughly assess the impact of a code before it is adopted. We need to ask ourselves, 'Does it solve one problem and create another?'" Mr. Hammerman developed an "Impact Assessment Guide for Analyzing Technical Code Statements" which can be used to objectively evaluate, affirm, or reject the credibility of a code change proposal, existing code statement, or new methodology.

Using the guide, regulators can summarize the purpose of the code and develop an assessment or problem statement, establish benefits, describe methods to achieve the desired results and present an evaluation plan, then delineate costs and financial considerations as well as moral and political considerations. For a copy of the guide, contact the NCSBCS Communications Department.

For more information on the NAHB task force and FRT plywood, contact William Young, NAHB, at (202) 822-0409.

WILLIAM M. CONNOLLY, AIA

William M. Connolly is Director of the New Jersey Division of Housing and Development. The Division implements and administers construction codes, including building, plumbing, fire protection, electrical, energy conservation and mechanical codes, at the state and local levels, a state-enforced maintenance housing code for hotel and multiple dwellings, a state new home warranty program, a state boarding home licensing effort, neighborhood preservation and housing rehabilitation programs, a 10,000 unit "Section 8" low income housing subsidy program, the federal small cities community development block grant program and a state Uniform Fire Safety Code.

A registered architect, Mr. Connolly has been with the State of New Jersey for fifteen years. Before that he was engaged in the private practice of architecture. He also served two years in construction operations with the Corps of Engineers including one year in the Republic of Viet-Nam.

Mr. Connolly has been the New Jersey delegate member to the National Conference of States on Building Codes and Standards for thirteen years and is a Director and Past President of that organization. He also serves as a Director of the National Institute of Building Sciences. Mr. Connolly is a member of the American Institute of Architects, Building Officials and Code Administrators International, where he served as the Chairman of the State Building Officials Committee, and the National Association of Housing and Redevelopment Officials. He also served as the first Chairman of the Board of Governors of the National Certification Program for Construction Code Inspectors. He serves on a number of New Jersey state government committees including: Cabinet Committee on Permit Coordination; Cabinet Committee on Boarding Homes; New Jersey Arson Task Force; and the Asbestos Task Force. Mr. Connolly also served for a number of years as chairman of the planning board in two different municipalities and as a member of the City of Plainfield's Downtown Policy Committee.

Mr. Connolly earned his Bachelor of Architecture from the University of Notre Dame.

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Mr. WALGREN [presiding]. Thank you very much, Mr. Connolly. Mr. O'Grady.

**STATEMENT OF JOSEPH G. O'GRADY, PRESIDENT, THE AMERICAN SOCIETY FOR TESTING AND MATERIALS, PHILADELPHIA, PA**

Mr. O'GRADY. Thank you, Mr. Chairman.

It is a pleasure once again for me, as the President of ASTM, to appear before this committee to—as some of my colleagues before me have said, to plead for the preservation of certain elements of the National Institute of Standards and Technology which, in my judgment, need to be preserved.

The history of ASTM is known to this committee and is part of the record, so I will not use the time allotted to repeat it.

But I would like to point out, however, that ASTM is considered by many to be the leading organization in the development of voluntary consensus standards in the United States. Indeed, it may very well be throughout the world.

Last year, we produced 8,500 voluntary standards that are used in both national and international trade, and it is no secret that ASTM is a friend of the Institute, as, indeed, the Institute has been a friend to us.

The integrity and reputation of its scientists is known far and wide, and we take great pride that that integrity and reputation is part of our own.

I would like to add another word here. In addition to integrity and reputation among the scientists of NIST, there is another word that needs to be used. It is called "commitment."

The scientists of NIST play a great role in the development of voluntary consensus standards for ASTM and others. They contribute their talents and experience to ASTM and others to the development of standards for our national industrial products, national health and safety, and quality of life.

The work of the National Institute of Standards and Technology creates the basic substructures upon which many ASTM standards are built. When the basic substructure is strong, the standards that we develop reflect that strength. We count on and have great need for the basic research, the reference material program and advanced measurement techniques that can only be developed by the Institute.

Now, Mr. Chairman and members of the committee, I am aware that the budget process and organization of any government agency is indeed complex. We must admit, and I do admit, that I do not feel competent to attempt to direct the course of either, even if the not-for-profit charter of ASTM would permit it.

The only exception we ever make to our own rule is at this time of year, almost every year now, when this subcommittee considers the NIST budget request. We do this only because it affects ASTM directly. We will therefore confine our remarks to only those areas that are related to the activities of ASTM.

Those NIST programs that impact our work in a major way are, among others, measurement research and standards, materials science and engineering and engineering measurements and stand-

ards, particularly the construction and performance of buildings and fire protection.

As was mentioned earlier, the entire voluntary standards in America is now face to face with a unified and stronger standards system in Europe, and we are face to face with the initiatives created by other national standards organizations from around the world whose technologies are in fact gaining in strength and gaining in rate of development.

Today, ASTM technology is known and applied around the world. The reason for this is the integrity of the technical document, the quality, if you will, of our product. ASTM is in fact recognized and its standards are used widely throughout the world.

It enjoys this credibility and demand because of the system that fosters it—due process and consensus requirements and through the cooperation and the technical contributions of our government scientists through their laboratories, through their equipment, their research and, most important to us, through their places in our technical committees.

Today our standards compete for use around the world in a spectacular fashion. They are the standards that address our national needs, and they are also in many areas de facto international standards. Tomorrow is a challenge. Tomorrow is indeed a challenge, and, Mr. Chairman, this is not the time for reductions in technical strength of NIST.

Reductions in fire and building research in chlorofluorocarbons and modest increases, and only modest increases, in chemical measurement and composites, for example, in my opinion would be a crucial, critical problem in the near term.

It is in these very areas where our colleagues abroad are making great strides in combining the best of their technologies. To cut back now is to lose whatever edge we may still possess.

While we understand the importance of new technologies, the more stable ones still remain the backbone of American industries, two of which have been repeated here repeatedly during the day, the Center for Building Technology and the Center for Fire Research.

We simply as a nation cannot afford to relinquish the development of these technologies to other countries. It is difficult, we know, to expand the responsibilities of the Institute while keeping intact its primary metrology functions, but we at ASTM have had to face the same demands since the year of our inception. We have always had to respond to the demands of emerging technologies while simultaneously supporting and improving the core technologies which made our system great, as indeed has made NIST the envy of the world.

For that reason we must voice some particular concern about the proposed reductions for the Centers for Building Technology and Fire Research. The need for a stable level of building technology and fire research does not diminish beside the emergence of newer technologies. Certainly, the activities of our technical committees in these areas have not decreased—I am talking now about fire research and building technology—the activities of our technical committees have not decreased, nor have the committees indicated

a lessening of the need for advancement and improvement in these areas.

Indeed, they are as active as ever and are experiencing new problems and challenges that will require the application of the kinds of basic research that have been traditionally performed by the centers at NIST.

I, therefore, Mr. Chairman, recommend to the Committee and urge the Committee, plead with the committee to do everything you possibly can to restore the funding cuts which are proposed in the current budget.

More generally speaking, we think any budget must provide for inflation in a very real way. To paraphrase an old colleague of yours, a little inflation here and a little inflation there and pretty soon you are talking about some real money.

Real money for NIST means the best laboratory equipment, the access to which directly affects the quality of our standards documents. Real money also means travel allowances for scientists to take part in our technical committee activities.

If we are understanding this budget request correctly, it does not realistically address the inflation factor with a figure of one-half of 1 percent. We therefore urge the committee to reconsider and increase the inflationary factor to an appropriate level.

Mr. Kammer, the Acting Director of the Institute, appeared before this subcommittee on March 7th and delivered a testimony that has impressed us profoundly. His account of the accomplishments of NIST have only served to increase our confidence and admiration for this national laboratory, which has worked for so many years as a partner in the development of our standards and thereby the strengthening of American industries and the reinforcement of American industries in their competitive position overseas.

As we hear the status of exciting new research projects, we can see in them the direction of our own future, and while we have stated the need for strengthening the more stable technologies, we do not mean to imply and we do not imply that the new frontiers are less important.

We have addressed a few critical points in our brief testimony today, which only approaches a full expression of the value of the Institute's contributions to us and to this government and to the country we both serve.

So once again, Mr. Chairman, my sincere thanks for the opportunity to be here, and once again, and finally the last one on the panel, the last person to give testimony repeats on behalf of all my colleagues before me, please do everything you can to restore the budget cuts that are proposed for NIST.

Thank you very much.

[The prepared statement of Mr. O'Grady follows:]

# Statement of Joseph G. O'Grady

**President of ASTM**

**on the**

**National Institute of Standards and Technology FY'90 Budget**

**Submitted to the**

**Subcommittee on Science, Research and Technology**
**of the Committee on Science, Space and Technology**
**of the United States House of Representatives**

**March 23, 1989**

STATEMENT OF JOSEPH G. O'GRADY

PRESIDENT OF ASTM
ON THE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY FY'90 BUDGET

SUBMITTED TO THE
SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY
OF THE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
OF THE UNITED STATES HOUSE OF REPRESENTATIVES

MARCH 23, 1989

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE. THANK YOU FOR THE OPPORTUNITY TO APPEAR THIS MORNING. THE HISTORY OF ASTM IS KNOWN TO THE SUBCOMMITTEE AND IS PART OF THE RECORD SO I WILL NOT USE THE TIME ALLOTED FOR US TODAY TO REPEAT IT. I SHOULD LIKE TO POINT OUT, HOWEVER, THAT ASTM IS THE LEADING ORGANIZATION IN THE WORLD FOR THE DEVELOPMENT OF VOLUNTARY CONSENSUS STANDARDS. LAST YEAR, WE PRODUCED OVER 8,000 DOCUMENTS. IT IS NO SECRET THAT ASTM IS A FRIEND OF THE INSTITUTE AS INDEED IT HAS BEEN A FRIEND TO US. THE INTEGRITY AND REPUTATION OF ITS SCIENTISTS IS KNOWN FAR AND WIDE AND WE TAKE GREAT PRIDE THAT THAT INTEGRITY AND REPUTATION IS A PART OF OUR OWN. THE SCIENTISTS OF NIST PLAY A GREAT ROLE IN THE DEVELOPMENT OF VOLUNTARY CONSENSUS STANDARDS. THEY CONTRIBUTE THEIR TALENTS AND EXPERIENCE AT ASTM TO THE DEVELOPMENT OF STANDARDS FOR OUR NATION'S INDUSTRIAL PRODUCTS, ITS HEALTH AND SAFETY, AND ITS QUALITY OF LIFE.

THE WORK OF THE NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY CREATES THE BASIC SUBSTRUCTURES UPON WHICH MANY ASTM STANDARDS ARE BUILT. WHEN THE BASIC SUBSTRUCTURES ARE STRONG, THE STANDARDS THAT WE DEVELOP REFLECT THAT STRENGTH. WE COUNT ON AND HAVE GREAT NEED FOR THE BASIC RESEARCH, REFERENCE MATERIALS, AND ADVANCED MEASUREMENT TECHNIQUES THAT CAN ONLY BE DEVELOPED BY THE INSTITUTE.

THE BUDGET PROCESS AND ORGANIZATION OF ANY GOVERNMENT AGENCY IS COMPLEX. WE MUST ADMIT THAT WE DO NOT FEEL COMPETENT TO ATTEMPT TO DIRECT THE COURSE OF EITHER, EVEN IF OUR NON-PROFIT CHARTER PERMITTED US TO DO SO. THE ONLY EXCEPTION WE EVER MAKE TO OUR OWN RULE IS THIS TIME EVERY YEAR, WHEN THIS SUBCOMMITTEE CONSIDERS THE NIST BUDGET REQUEST. WE DO THIS ONLY BECAUSE IT AFFECTS ASTM DIRECTLY. WE WILL, THEREFORE, CONFINE OUR REMARKS TO ONLY THOSE AREAS THAT ARE RELATED TO THE ACTIVITIES OF ASTM. THOSE NIST PROGRAMS THAT IMPACT OUR OWN WORK IN A MAJOR WAY ARE, AMONG OTHERS, MEASUREMENT RESEARCH AND STANDARDS, MATERIALS SCIENCE AND ENGINEERING, AND ENGINEERING MEASUREMENTS AND STANDARDS, PARTICULARLY THE CONSTRUCTION AND PERFORMANCE OF BUILDINGS AND FIRE PROTECTION.

THE ENTIRE VOLUNTARY STANDARDS SYSTEM IN AMERICA IS NOW FACE TO FACE WITH A UNIFIED AND STRONGER STANDARDS SYSTEM IN EUROPE, AND WITH OTHER NATIONAL STANDARDS SYSTEMS AROUND THE WORLD WHOSE TECHNOLOGIES ARE GAINING IN STRENGTH AND RATE OF DEVELOPMENT. TODAY, ASTM TECHNOLOGY IS KNOWN AND APPLIED AROUND THE WORLD. THE REASON FOR THIS IS THE INTEGRITY OF THE TECHNICAL DOCUMENT, THE QUALITY, IF YOU WILL, OF THE PRODUCT. IT ENJOYS THIS CREDIBILITY AND DEMAND BECAUSE OF THE SYSTEM THAT FOSTERS IT, AND THROUGH THE COOPERATION AND THE TECHNICAL CONTRIBUTIONS OF OUR GOVERNMENT SCIENTISTS, THROUGH THEIR LABORATORIES, EQUIPMENT, RESEARCH, AND MOST IMPORTANT TO US, THROUGH THEIR PLACES ON OUR TECHNICAL COMMITTEES. TODAY, OUR STANDARDS COMPETE FOR USE AROUND THE WORLD IN A SPECTACULAR FASHION. THEY ARE THE STANDARDS THAT ADDRESS OUR NATIONAL NEEDS, AND THEY ARE ALSO IN MANY AREAS, DE FACTO INTERNATIONAL STANDARDS. TOMMORROW IS A CHALLENGE. THIS IS NOT A TIME FOR REDUCTIONS IN TECHNICAL STRENGTH.

REDUCTIONS IN FIRE AND BUILDING RESEARCH, IN CHLOROFLUOROCARBONS AND MODEST INCREASES IN CHEMICAL MEASUREMENT AND COMPOSITES, FOR INSTANCE, COULD BE A CRITICAL PROBLEM. IT IS IN THESE VERY AREAS WHERE OUR COLLEAGUES ABROAD ARE MAKING GREAT STRIDES IN COMBINING THE BEST OF THEIR TECHNOLOGIES. TO CUT BACK NOW IS TO LOSE WHATEVER EDGE WE MAY STILL POSSESS. WHILE WE UNDERSTAND THE IMPORTANCE OF NEW TECHNOLOGIES, THE MORE STABLE ONES STILL REMAIN THE BACKBONE OF MANY AMERICAN INDUSTRIES. WE SIMPLY CANNOT AFFORD TO RELINQUISH THE DEVELOMENT OF THESE TO FOREIGN COUNTRIES.

IT IS DIFFICULT, WE KNOW, TO EXPAND THE RESPONSIBILITIES OF THE INSTITUTE WHILE KEEPING INTACT ITS PRIMARY METROLOGY FUNCTIONS, BUT WE AT ASTM HAVE HAD TO FACE THE SAME DEMANDS SINCE THE YEAR OF OUR INCEPTION. WE HAVE ALWAYS HAD TO RESPOND TO THE DEMANDS OF EMERGING TECHNOLOGIES, WHILE SIMULTANEOUSLY SUPPORTING AND IMPROVING THE MORE STABLE ONES.

FOR THAT REASON, WE MUST VOICE SOME PARTICULAR CONCERN ABOUT THE PROPOSED REDUCTIONS FOR THE CENTERS FOR BUILDING TECHNOLOGY AND FIRE RESEARCH. THE NEED FOR A STABLE LEVEL OF BUILDING TECHNOLOGY AND FIRE RESEARCH DOES NOT DIMINISH BESIDE THE EMERGENCE OF NEWER TECHNOLOGIES. CERTAINLY THE ACTIVITIES OF OUR TECHNICAL COMMITTEES IN THESE AREAS HAS NOT DECREASED NOR HAVE THEY INDICATED A LESSENING OF THE NEED FOR ADVANCEMENT AND IMPROVEMENT IN THESE AREAS. INDEED, THEY ARE AS ACTIVE AS EVER, AND ARE EXPERIENCING NEW PROBLEMS AND CHALLENGES THAT WILL REQUIRE THE APPLICATION OF THE KINDS OF BASIC RESEARCH THAT HAVE TRADITIONALLY BEEN PERFORMED BY THESE CENTERS. WE URGE YOU, THEREFORE, TO RESTORE THESE PROGRAMS TO FULL FUNDING.

MORE GENERALLY SPEAKING, WE THINK ANY BUDGET MUST PROVIDE FOR INFLATION IN A VERY REAL WAY. TO PARAPHRASE AN OLD COLLEAGUE OF YOURS, A LITTLE INFLATION HERE, A LITTLE INFLATION THERE, AND PRETTY SOON YOU ARE TALKING REAL MONEY.

REAL MONEY FOR NIST MEANS THE BEST LABORATORY EQUIPMENT - THE ACCESS TO WHICH DIRECTLY AFFECTS THE QUALITY OF OUR STANDARDS DOCUMENTS. REAL MONEY ALSO MEANS TRAVEL ALLOWANCES FOR SCIENTISTS TO TAKE PART IN OUR TECHNICAL COMMITTEE ACTIVITIES. IF WE ARE UNDERSTANDING THIS BUDGET REQUEST CORRECTLY, IT DOES NOT REALISTICALLY ADDRESS THE INFLATION FACTOR WITH A FIGURE OF ONE HALF OF ONE PERCENT. WE URGE YOU TO CONSIDER INCREASING THIS FIGURE.

MR. KAMMER APPEARED BEFORE THIS SUBCOMMITTEE ON MARCH 7, 1989, AND DELIVERED A TESTIMONY THAT HAS IMPRESSED US PROFOUNDLY. HIS ACCOUNT OF THE ACCOMPLISHMENTS OF NIST HAVE ONLY SERVED TO INCREASE OUR CONFIDENCE AND ADMIRATION FOR THIS NATIONAL LABORATORY WHICH HAS WORKED FOR SO MANY YEARS AS A PARTNER IN THE DEVELOPMENT OF OUR STANDARDS AND THEREBY, THE STRENGTHENING OF OUR AMERICAN INDUSTRIES. AS WE HEAR THE STATUS OF EXCITING NEW RESEARCH PROJECTS, WE CAN SEE IN THEM THE DIRECTION OF OUR OWN FUTURE. AND WHILE WE HAVE STATED THE NEED FOR STRENGTHENING THE MORE STABLE TECHNOLOGIES, WE DO NOT MEAN TO IMPLY THAT THE NEW FRONTIERS ARE LESS IMPORTANT.

WE HAVE ADDRESSED A FEW CRITICAL POINTS IN OUR BRIEF TESTIMONY TODAY, WHICH ONLY APPROACHES A FULL EXPRESSION OF THE VALUE OF THIS INSTITUTE'S CONTRIBUTIONS TO US, AND TO THIS GOVERNMENT AND COUNTRY WHICH WE BOTH SERVE.

I WOULD LIKE TO CLOSE, MR. CHAIRMAN, BY EXPRESSING MY APPRECIATION AGAIN TO THIS SUBCOMMITTEE FOR THE OPPORTUNITY TO APPEAR AND TO SAY TO YOU THAT WE TAKE GREAT ENCOURAGEMENT FROM YOUR RECOGNITION AND SUPPORT OF OUR NATION'S NATIONAL LABORATORY, ONE OF OUR COUNTRY'S GREATEST ASSETS.

# PRESIDENT

**JOSEPH G. O'GRADY**
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**Joseph G. O'Grady**, president of ASTM, is a native of North Bergen, New Jersey. He received a B.E.E. degree in 1954 from the College of Engineering of New York University.

O'Grady joined the ASTM staff as executive vice president in January 1984. He assumed its presidency in June 1985. Prior to this, O'Grady served as vice president of the PSE&G Research Corporation, a wholly owned subsidiary of Public Service Electric and Gas Company of New Jersey, and directed the activities of the corporate Research and Testing Laboratory in Maplewood, New Jersey.

During his tenure at PSE&G, O'Grady served as a volunteer member of ASTM on several technical committees, including those on petroleum and atmospheric analysis. He was elected to ASTM's Board of Directors in 1973 and served as its chairman during 1978-79.

O'Grady served on the National Executive Committee of the Consultative Council of the National Institute of Building Sciences from 1981 to 1985, and is currently serving as a member of the Board of Directors of the institute. He also serves as a director of the Materials Property Council and is a member of the Industry Functional Advisory Committee on Standards, which is jointly sponsored by the U. S. Department of Commerce and the Office of the U. S. Trade Representative. He was also recently appointed Executive Director of the Institute for Standards Research, a subsidiary of ASTM.

A registered professional engineer in the state of New Jersey, O'Grady is a member of the National Association of Corrosion Engineers, the Standards Engineering Society, the Council of Engineering and Scientific Society Executives, and the Newcomen Society. He is a past director of the American Association of Laboratory Accreditation and past chairman of the Executive Advisory Committee of the Codes and Standards Committee of the Edison Electric Institute.

Mr. WALGREN. Thank you very much, Mr. O'Grady. I appreciate that.

The gentleman from California.

Mr. BROWN. Well, let me assure the gentleman and all of you that the odds are highly favorable that this committee will do its part to restore those cuts. Now, unfortunately, we are not the only actors in this game and we need a strategy to get to some of the other actors as well, and I am optimistic that we will be able to succeed in this as we have in the past.

But our success in the past has not been unqualified, as you know. We have saved the fire research and building research institutes at the expense of some of the other programs in NIST or at some loss to them, shall we say, and this is not a condition that we can continue to have because it is becoming much more critical that we provide additional resources throughout the structure of NIST.

I am not going to dwell on that further. I want to deal with just this one issue that you raise, Mr. Braswell, the CFC issue, because in a sense this is a prototype of a situation that faces us throughout our society today.

I, over in the Ag Committee work on a regular basis with the need to phase out chemicals in agriculture, for example, Alar being one that is much in the headlines today. EDB was a few years back, others all the time. Increasing knowledge about health and safety, environmental and other effects requires us to adapt to these things with new products and new processes, and the industry that you represent and speak for is now confronted with that. You probably don't face it as often as the agricultural chemical people do and some others, but you face it now and we are going to deal with it.

We are going to have to face it in the fuels, where we are going to have to cut back on the use of gasoline. We are going to face it in the utility industry, where we may cut back on the use of coal and oil.

And what I am looking at, what we in this committee look at is how we can face this in a way that is beneficial to American industry, how we can see it as opportunities and markets, not just as government meddling in the affairs of business, which is the way it gets presented all too often.

We don't meddle in the affairs of business unless our reelection depends on it. [Laughter.]

Believe me, and this is the situation that confronts us.

On CFCs we now have a national commitment to phase them out, we have an international commitment to phase them out, we have increasing political pressure building up not just in this country but around the world, and we have a whole series of problems that are caused by this as to how do we do it.

Now, how we are doing it here, we are cutting a quarter of a million dollars out of NIST's budget to help achieve a better understanding of what we need here, and that is ridiculous. What we should be doing—and in order to put this as a question, I will ask you if you will confirm this—is to see it as an opportunity and to devote additional resources to making this transition easier and seizing upon the possibility of creating a new generation of technol-

ogy, both in terms of the refrigerants but in terms of equipment, which might meet the need on a global basis to resolve this problem of CFC release and its impact upon the global environment.

Do you see this as a reasonable way for this country to proceed instead of just fighting a battle as to how fast we can do this without looking at the opportunities?

Mr. BRASWELL. Well, if I understand your question correctly, Mr. Brown, we do indeed agree. This is an opportunity.

Of course, it is, as I discussed, a problem for us to solve, a very important problem.

Mr. BROWN. Of course.

Mr. BRASWELL. And the time urgency is the problem which makes it more difficult for us and which generates the need for some assistance from people like—from organizations such as NIST.

But, indeed, it is also an opportunity to advance our technology, to make ourselves more competitive in the world market, and indeed many of our companies do participate actively in the world marketplace because for many years we have been the leaders in the field of refrigeration and air conditioning equipment. We would like to continue to be so.

But it is indeed possible if other nations now take advantage of this opportunity to get ahead of us that we could slip further behind, and we have been slipping a little behind in recent years in terms of the ratio of our exports to imports, although we still have a positive balance, fortunately, in our industry.

We could face increasing competitive pressures abroad in the world markets where our companies are active as well as increasing pressures in this country if other nations are able to take advantage of this new technology and adapt faster than we can adapt or faster than we do adapt to this new situation.

Mr. BROWN. Well, what I am looking for is how we can create this broad focus on new technology developments which we can pioneer and be the world's leader in, continue to be the world's leader in.

Du Pont, which makes, what, 25 percent of all of the CFCs on a worldwide basis, is not necessarily interested in the kind of refrigerators that use them, for example. They meet the demand of the refrigerator manufacturers.

What we need here is to have some leadership from the federal government in encouraging the Du Ponts, who manufacture their products, to cooperate with the GEs, who manufacture their product, with a little government effort, assistance, to come up with, shall we say—and I am just taking this off the top of my head—a new generation of home refrigeration equipment?

Mr. BRASWELL. Well, I think you will find that that cooperation is occurring between the chemical producers and the equipment manufacturers——

Mr. BROWN. Good.

Mr. BRASWELL [continuing]. Both in our industry and in the refrigerator industry as well.

So I don't think that the Government needs to prod those industries to take that action. They are cooperating.

The problem is that because of the complexity of the task and the time in which we have to accomplish it, it is going to require a coordinated effort, not only between the chemical producers and the equipment manufacturers, but also with the government assisting and providing technical assistance in every way that is possible for the government to assist so that we can avoid duplicative or redundant work in the industry.

Mr. BROWN. Well, what was just going through my mind is how the Japanese respond to a challenge like this and how far removed we are from achieving that same level of response when we—it doesn't take any imagination to see the market possibilities here. It is forced on us, as a matter of fact.

We don't have to invent some new product or new way of serving market needs. We have to take advantage of one that we know is here, and we should be able to do that in a more effective way than we have been.

Thank you.

Mr. WALGREN. Thank you, Mr. Brown.

Well, I think I would just like to express appreciation to you all for the direct support that you have given to the programs that we oversee as a committee, and I think in the interest of time we can end at this point.

I would like to thank you as a panel, on behalf of the committee, for what you have given to coming and presenting this testimony, and I want you to know that we look forward to hearing from you and interacting with you individually as the need arises as we go through this process. So we consider you a resource to us and appreciate you very much in that sense.

So thank you very much, and with that we will end the hearing.

[Whereupon, at 12:52 p.m., the subcommittee was adjourned, subject to the call of the Chair.]

# APPENDIX

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(formerly National Bureau of Standards)
Gaithersburg, Maryland 20899
OFFICE OF THE DIRECTOR

JAN 31 1989

Honorable Robert A. Roe
Chairman
Committee on Science, Space and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

House Report No. 100-673, Part I, requests the National Institute of Standards and Technology (NIST) to submit to the Congress a report on the present and future needs of NIST's supercomputer facilities. I am enclosing a copy of our report on the Computing Needs of the Consolidated Scientific Computing System.

The present central computing facility serves the scientific and technical computing needs of NIST and the Environmental Research Laboratory of the National Oceanic and Atmospheric Administration. It is currently utilized at full capacity. A request for funds to enhance the system is included in the President's FY 1990 budget.

New design and operating systems make it possible to design a modular configuration of computers that provide the necessary increase in power in forms that are flexible and easy to modify and upgrade, all at a modest cost. The NIST proposal would include a modestly sized supercomputer, a small number of mini-supercomputers, a large mass storage device, and powerful very-high-speed communications links.

If you have any questions or would like additional information, our Congressional Affairs Director, Esther Cassidy, will be pleased to help you. She can be reached at 975-3080.

Sincerely,

Raymond G. Kammer
Acting Director

Enclosure

# COMPUTING NEEDS OF THE CONSOLIDATED SCIENTIFIC COMPUTING SYSTEM (CSCS)

## *EXECUTIVE SUMMARY*

The present central computing facility (Consolidated Scientific Computing System - CSCS) serving scientific and technical computing needs of NIST and ERL (of NOAA) was installed in the spring of 1985 and reached saturation in less than two years. A request for funds to enhance the system is included in the President's FY 1990 budget. Replacement equipment is urgently needed by both agencies and this request has received very high priority from NIST, the submitting agency.

Recent developments in the design and operating systems of computers make it possible to design a modular configuration of computers that provide the necessary increases in computing power in a form that is flexible, well matched to the diversity of typical use patterns, and easy to modify or upgrade, all at modest cost. The NIST proposal envisages a modestly sized supercomputer, a small number of mini-supercomputers each emphasizing a different type of use:

- many interactive users, short runs, small memory
- large memory, few users, medium length runs
- high speed input-output for graphics applications

along with a large mass storage device and powerful very-high-speed communications links. Experience has shown that although a top-of-the- line supercomputer is unsurpassed for the most demanding problems, it is not nearly as cost-effective as the above system for the variety of usage at NIST and ERL.

All component equipment will be required to function in the UNIX operating system which is becoming the system common to most new scientific computers. This commonality will make it possible to solicit many vendors for different components or replacements based on needs for special features, new technologies, and attractive prices. It will also make possible the easy transfer of data and files from one machine to another, and it will easily accommodate communication with the large number of increasingly powerful workstations which are beginning to be used by many scientific groups in local computations involving problems of intermediate size.

## Introduction

One of the central concerns of NIST is the need of industry for reliable technical and scientific data about materials and processes, based as needed on the most accurate available measurements, and using measurement standards that are commonly accepted on a national and international level and it maintains a close relationship with industry toward these ends. All major units of NIST are reviewed annually by panels on which representatives of interested industries play an important part.

The central computing facilities at NIST are designed and operated to support the scientific and engineering programs of NIST and ERL. They play a critical role in the execution of the missions of the two agencies. The range of demands for their services is expanding rapidly as more and more applications come on line and become known, and the power of computer technology increases.

The computing facility is used to enable the technical and scientific groups at NIST to keep at the leading edge of developments in technology and science as they pertain to its major missions. Thus, they engage in computations to refine the means by which very small intervals of time are measured (useful, for example in space satellite measurements), or to identify intermediate chemical products that exist, very briefly, during high-speed chemical processes (to make possible accurate measurements of these products and to develop methods of controlling them), or to obtain data about the cross-sections and other properties of many atomic or molecular interactions needed for a wide variety of purposes ranging from industrial chemistry to scientific studies to identification fo pollutants in the environment.

Computers also provide means of simulating experiments to yield data that could not be obtained directly in the course of an experiment (because it is possible to obtain measures of some quantities from computer output that it might be impossible to obtain from a physical experiment,- in which an explosion occurs, for example), or to simulate relatively inexpensively experiments that would be very expensive to carry out physically.

It is also necessary to have powerful computing equipment in order to match up effectively with the facilities available to high-technology industrial laboratories, and to maintain a common understanding of state-of-the-art techniques and methods. This requires, in fact, that NIST scientists, engineers and scientific computing experts maintain a position among the leaders in advanced scientific computing methods and facilities.

It should be noted that, although the diversity of computing requirements for ERL is much less than that at NIST, they too are faced with very demanding problems in trying to develop better models for the extremely complex phenomena that characterize the weather (and the near- catastrophic events such as hurricanes and cyclones) and the movements of the oceans. Analysis of such phenomena can only begin to be studied with the most powerful computers now in existence.

The Consolidated Scientific Computing System (CSCS) was established in 1985 to serve the computing needs of the scientific and engineering communities of NIST, ERL, and NTIA - the National Institute of Standards and Technology (formerly NBS), the Environmental Research Laboratories of NOAA, and the National Telecommunications and Information Administration, respectively. It consists of a Cyber 205 supercomputer and a front-end (and also independently functioning) Cyber 855 at NIST-Gaithersburg and a Cyber 840 at Boulder, along with a communications net between those stations and other ERL sites. It was installed in the spring of 1985 and reached saturation in less than two years. NIST, as the agency responsible for the direction of CSCS, thereupon initiated steps to upgrade the facility. As a result of this planning, the President's budget for FY 1990 includes funds for this purpose. NIST has given this request very high priority because of its importance to the effective implementation of its missions.

## System Description

NIST has proposed that the present system be replaced in its entirety by one that takes advantage of the most recent advances in computer design to provide not only the necessary increases in computing power, but also a configuration in which component units match different typical patterns of use, and which can be modified easily and economically in the future to encompass change and growth. This is achieved by a modular design, including a modestly sized supercomputer, a small number of minisupercomputers, a mass data storage device, and a very-high-speed communication net, all configured to be compatible with each other and with standards common to a significant number of computer manufacturers. Such a system can be obtained at modest cost, with adequate power for the present, and with great flexibility in adapting it to changing needs and to new, more advanced, computers as they come on the market in the future. The system is outlined in Figure 1. The "large memory," "interactive," and "visualization" machines are expected to be mini-supercomputers.

The configuration of the proposed system is based on a careful analysis of the patterns of usage and applications of the agencies which it supports. These

differ greatly. Usage is concentrated in NIST and ERL; on the supercomputer, NIST occupies more than 60% of the available time, and ERL takes up close to 40%. Because of the dispersion and missions of its sites, ERL tends to look to the central facility mainly for sheer capacity, which enables them to run large codes, generally of unchanging or slowly changing form, to analyze data or the effects of different inputs to standardized models of atmospheric phenomena. NIST, on the other hand, is characterized by very great diversity, and it is this which has led to the concepts of modularity underlying the proposal that go beyond the simple augmentation of computing power.

## Discussion

Nearly all supercomputer applications at NIST are carried out by individual staff members. For the most part they do not use prepared, "package", programs, but rather they devise their own programs, or major parts of them, in order to accommodate individual project assignments, which generally have unique aspects that require special formulation because they are at the forefront of current development in their fields of specialization. Their computer activity varies among several phases, including:

1. writing or editing of code, interspersed with test runs to check validity, or accuracy, or speed of component parts of the code; these generally require many long sessions of interactive access to a computer, at which the results of each short run must be obtained without delay in order to be able to proceed with further development.

2. intensive use of the supercomputer for an extended period to obtain detailed, accurate results, with a number of long runs to evaluate the effects of different parameters of their problem.

These may be followed by an interval in which no computing is done, while results are applied or compared with experimental results, which may then be followed in turn by new formulations requiring significant reprogramming, as in phase one. Their computer usage, as a results is likely to wax and wane, with flexible interactivity important at one point, and number crunching at another; detailed graphic output during complicated calculations may be essential to obtain insight into the highly detailed results.

Each of the phases may extend over weeks or months, with many different scientists or engineers engaged in one or another of the phases at any one time.

As a result, it becomes both economical and helpful to provide various types of computers that are less expensive than the supercomputers for all but the "number crunching" phases. The scope and diversity of computer requirements at NIST are outlined in the following list:

- Fast interactive operations involving frequent shifts between code editing, compiling and one-shot short programs with small memory requirements, to support efficient use of staff time;
- Large memory requirements with relatively short running times;
- Extended non-interactive sessions of short programs that must be run thousands of times to obtain statistical results characterizing averages over a large number of parameter values, and in which the vectorization that provides speed in current supercomputers cannot be exploited, requiring very high speed and long residence on a computer;
- Graphics-interactive sessions for long-running programs that require frequent graphical display of results obtained in the course of a single computer run, - this implies very-high-speed connections to very powerful graphics devices;
- Large memory requirements and very long running times, needing as much computing power as can be provided;
- Large standard or packaged programs, either specifically written for a continuing group activity or obtained commercially for a fee, in which speed is important but not critical but which consume significant amounts of computer resources (such as input and output).

Contrary to common assumptions, a "single-instrument," top of the line supercomputer, is not the most effective tool for the mix of problems here described. A "powerhouse" is not designed to handle a load of interactive users, for example, and cannot handle the 60 to 80 users that normally log on to our present system, and even less so for the increased numbers that may appear in the future. Furthermore, in the competition for use of computer time during prime hours, priority must be given to the considerable number of interactive and other short problems run by people who work only during the daytime, and who would otherwise be confined to a highly unsatisfactory few short runs each day. But this means that the larger problems must be consigned to share the night time, where

they must compete within a 12-hour rather than 24-hour time frame; time-sharing scheduling generally leads to one hour or less each night and a 5-hour problem, for example, turns into a 5-day job.

Considerations of these kinds point strongly to the effectiveness of a modular system, consisting of a collection of computers, differently designed, and if necessary, from different manufacturers, which are configured individually to accommodate optimally one or another of the needs described above. The units of the system must be selected to be highly compatible, so that codes and files can readily be transferred from one unit to another, and users do not have to learn several different operating systems or languages. With the establishment of the Unix operating system as the most popular operating system among scientific groups, and its incorporation in nearly all scientific computers, compatibility can readily be achieved. It also provides for easy interchange of scientific codes between groups at different institutions.

A very high speed communication net is an essential component of our next system, not only in order to provide rapid transport of codes and data from one computer to another, but also to provide a high speed link between these computers and local area networks of specialized groups or workstations of individual staff members. Workstations are rapidly assuming a central role in scientific computing because of their ability to provide highly effective computers for smaller problems and for the initial stages of large problems. As their power increases, and costs come down, the way in which computing is carried out in larger organizations and laboratories will be drastically modified, and new configurations of the central facility will have to be introduced.

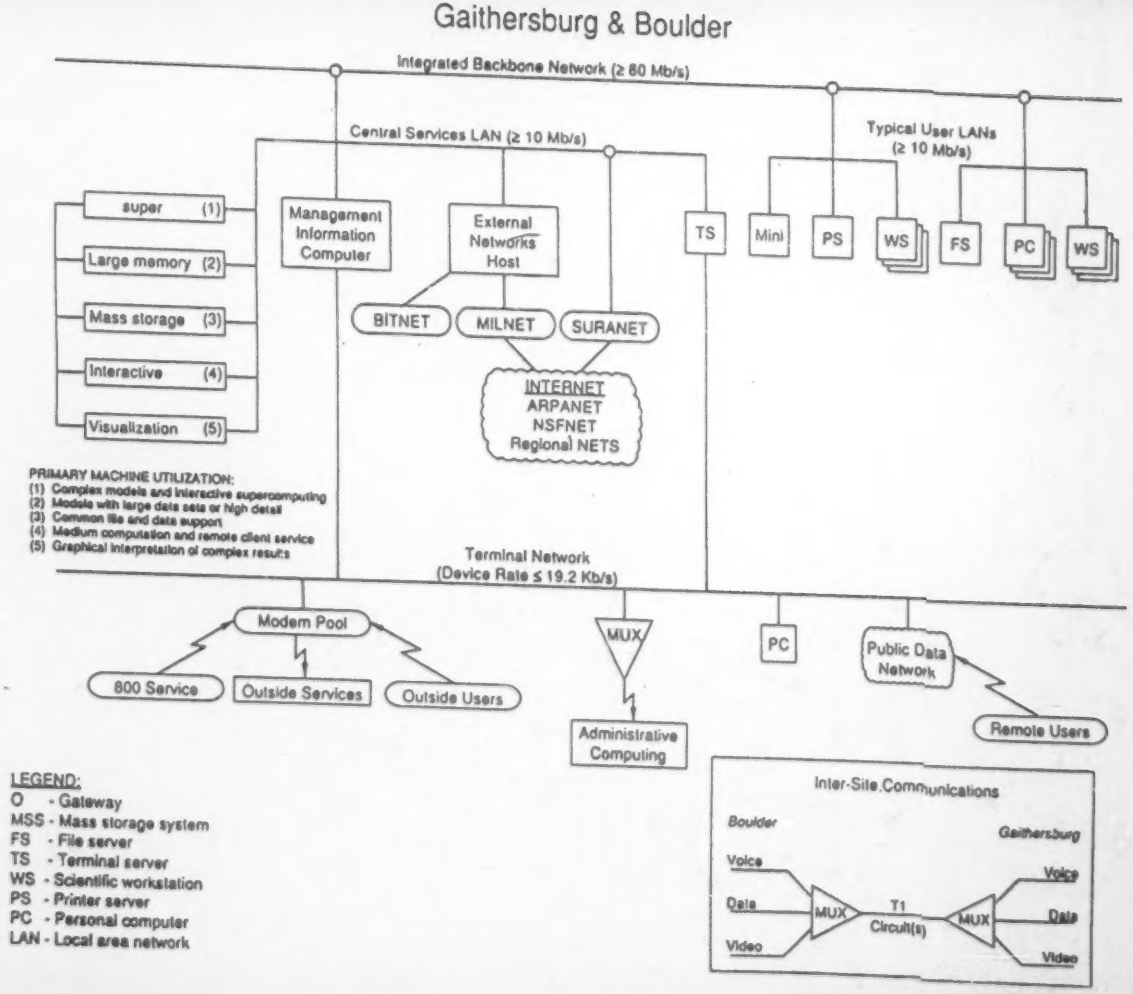
The foregoing considerations are the basis for the NIST proposal to acquire, on a lease basis, a modestly-priced supercomputer that will provide high (but not top) speed and a large memory and several minisupercomputers: one designed to accommodate simultaneously a large number of users running short problems or engaged in editing; a second with a particularly large memory but lower speed than a supercomputer: and another configured to handle input and output data at very high speeds, as needed for the large data flow to and from advanced graphics devices. A large mass storage device to store data for all the minisupers, along with a high-speed net will complement the selection of computers.

Minisupercomputers can now be obtained at relatively low lease cost, and not all of those mentioned here need be acquired at once. New designs can be added as they come to the market and provide special features of value to NIST or ERL. The value to the users of different component units can be assessed,

and modifications made, without having to make major changes. If one type of computer is found to be very heavily utilized, it can be expanded, or another unit of similar characteristics can be acquired at relatively low cost and little readjustment. Also, as the state of the computer-design art increases, it will be possible to add units incorporating the new design advantages, again without having to reconfigure the system as a whole.

## Conclusion

As indicated by the high priority given to the program of upgrading the present computing facility, NIST considers the upgrade in the proposed form to be an essential element in maintaining its high standards in its mission of support for the scientific and technological activities of the nation.


Gaithersburg & Boulder
Integrated Backbone Network (≥ 80 Mb/s)
Central Services LAN (≥ 10 Mb/s)
Typical User LANs (≥ 10 Mb/s)
super (1)
Large memory (2)
Mass storage (3)
Interactive (4)
Visualization (5)
Management Information Computer
External Networks Host
TS
Mini
PS
WS
FS
PC
WS
BITNET
MILNET
SURANET
INTERNET
ARPANET
NSFNET
Regional NETS
PRIMARY MACHINE UTILIZATION:
(1) Complex models and interactive supercomputing
(2) Models with large data sets or high detail
(3) Common file and data support
(4) Medium computation and remote client service
(5) Graphical interpretation of complex results
Terminal Network
(Device Rate ≤ 19.2 Kb/s)
Modem Pool
800 Service
Outside Services
Outside Users
MUX
Administrative Computing
PC
Public Data Network
Remote Users
LEGEND:
O - Gateway
MSS - Mass storage system
FS - File server
TS - Terminal server
WS - Scientific workstation
PS - Printer server
PC - Personal computer
LAN - Local area network
Inter-Site Communications
Boulder
Gaithersburg
Voice
Data
Video
MUX
T1
Circuit(s)
MUX
Voice
Data
Video

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(formerly National Bureau of Standards)
Gaithersburg, Maryland 20899
OFFICE OF THE DIRECTOR

JAN 31 1989

Honorable Robert A. Roe
Chairman
Committee on Science, Space and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

House Report No. 100-673, Part I, requests the National Institute of Standards and Technology (NIST) to submit to the Congress a report on NIST research on smart building technology. I am enclosing a copy of the report.

A "smart" building is a building with sensors and computer-controls to allow the building to adapt to changing conditions without human intervention. These sensors and controls allow for the more efficient and economical management of a building. The Center for Building Technology at NIST is conducting research with the building controls industry to solve the technical problems which contribute to the financial risk involved in installing a building management system. NIST research focuses on the development of a standard communication protocol for Energy Management and Control Systems (EMCS), the development of diagnostic techniques, and the creation of a system to evaluate EMCS performance.

If you have any questions or would like additional information, our Congressional Affairs Director, Esther Cassidy, will be pleased to assist you. She can be reached at 975-3080.

Sincerely,

Raymond G. Kammer
Acting Director

Enclosure

# RESEARCH ON SMART BUILDING TECHNOLOGY

# AT THE

# NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

## INTRODUCTION

A "smart" building is a building with sensors and computer-control to allow the building to adapt to changing conditions without human intervention. Smart buildings represent an improvement over conventional buildings because they can be more productive work places by dynamically adapting the environment to the occupants' needs, safer by protecting against fire hazards and threats to physical security or property loss, and more economical by avoiding unproductive use of labor, energy, water, and other resources. The sensors and computer constitute a building management system which is the brain and nervous system of a smart building.

Private sector investment in smart building technology has been restrained by limited compatibility among components. The conventional means to assure compatibility, used for systems ranging from computers to home stereos to automated machine tools, is through recognized interface protocols. Because these protocols do not exist for building controllers, there is the real risk that a system cannot be upgraded as the technology improves, cannot be maintained by anyone other than the original vendor, and cannot be fixed if the performance does not meet expectations. The development of the required protocols requires generic research and development that no one company can be expected to perform because no one company can gain proprietary advantage from the results. For the research results to be effective, they must be shared with all manufacturers.

The Center for Building Technology at the National Institute for Standards and Technology (NIST) is conducting research with the building controls industry to solve the technical problems which contribute to the financial risk involved in installing a building management system. The current program focuses on the following three areas:

1. the development of a standard communication protocol for Energy Management and Control Systems (EMCS),
2. the development of diagnostic techniques, and
3. the creation of a system to evaluate EMCS performance.

## TECHNICAL PROGRAM SUMMARY

### EMCS Communication Protocols

To help the private sector develop standard communication protocols for the control of building services, NIST established a communication protocols laboratory to (a) assist in developing standard protocols for the exchange of information among systems developed by different vendors and among different levels within an individual system, (b) develop procedures for both performance and compliance testing, (c) provide testing and evaluation facilities for different protocols and for determining compliance of vendors' equipment with proposed standards, (d) develop and verify "reference implementations" of all proposed protocol standards, and (e) develop guide specifications, test methods, and diagnostic procedures for complex systems involving hardware and software especially those involving life safety where reliability and response under adverse conditions become critical.

### System Diagnostics

In fiscal year 1988, NIST developed a prototype computerized diagnostic method to detect faulty equipment in a building's air handling equipment using sensor data from an EMCS. The method uses a computer model of the air handling unit to determine optimum performance parameters under normal operating conditions and compares the predictive values of parameters with data measured in the field. The program informs the building operator that a problem exists, the source of the problem, and its possible cause. The plans for fiscal year 1989 include evaluating the system as a real-time monitor for a building and for troubleshooting faulty air handling systems.

### HVAC Emulator/BMS Tester

Research in fiscal year 1989 will include the development of a computerized system to emulate the performance of the heating, ventilation, and air conditioning systems (HVAC) of a building. This emulator is a computer which predicts the performance of a building, responds to a building management system (BMS) as if it were a real building, and determines the energy saved by a given building operating strategy. This system permits efficient comprehensive testing of building management systems.

## PRIVATE SECTOR INTERACTIONS

NIST transfers its results through cooperative work with the controls industry and the professional or trade organizations of those who design, install, operate, and maintain control systems. Specifically, a NIST staff member serves as chairman of the working group of the American Society of Heating, Refrigerating, and Air Conditioning Engineers (a private sector professional society) that is developing voluntary standards for communication protocols. NIST also provides

technical support to the Intelligent Building Institute (IBI) which brings together users, manufacturers, and installers of smart building components.

In addition, the private sector provides equipment for the NIST program. For example, energy management and control systems have been loaned to NIST for its communication protocols laboratory by two domestic manufacturers and discussions are underway to involve more companies in the program.

Finally, NIST sponsors symposia on smart building technology to transmit the latest results of NIST's work to industry and to permit industry representatives to provide guidance on NIST's research approach. These symposia supplement the annual formal reviews of the program by a private-sector panel selected by the National Research Council.

## BUDGET

The fiscal year 1989 budget for the smart building program is

| | |
|---|---|
| NIST funding: | $330,000 |
| Department of Energy: | 50,000 |

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

MAY 26 1989

JUN 5 1989

Honorable Robert A. Roe
Chairman, Committee on Science, Space,
and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Thank you for your cosigned letter offering the assistance of the House Committee on Science, Space, and Technology in ensuring the success of the Commerce Science and Technology (COMSCI) Fellowship Program. We certainly appreciate your concern. The Technology Administration is assigned management responsibility for this program. Lee W. Mercer, Deputy Under Secretary for Technology, assures me that his office is very close to hiring a Director and that the 1989 COMSCI Fellowship Program will, indeed, begin in September.

We appreciate the offer of your Committee to assist in making this program a success. As soon as the COMSCI nominations are received by the Director, we will notify the Committee staff of their backgrounds in the event that the Committee desires to interview one or more of the Fellowship candidates.

Sincerely,

Robert A. Mosbacher

[illegible]

U.S. HOUSE OF REPRESENTATIVES

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-6371

[illegible]

*April 13, 1989*

*Honorable Robert A. Mosbacher*
*Secretary of Commerce*
*Washington, DC 20230*

*Dear Mr. Secretary:*

*We are pleased to acknowledge receipt of the plan to implement the Commerce Science and Technology (COMSCI) Fellowship Program, dated March 22, 1989, submitted to Speaker Jim Wright in accordance with Section 5163(d) of the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418). The report was referred to the Committee on Science, Space, and Technology.*

*We have reviewed the report and find it to be consistent with the intent of Section 5163(d) and urge the Department of Commerce to implement the plan on schedule so that the first COMSCI class may begin in September, 1989. We suggest, if it has not already occurred, that a COMSCI program director be appointed in the immediate future so that this excellent program may go forward as quickly as possible. Please feel free to call on our Committee if we may be of assistance in making this program a success.*

*Sincerely,*

*ROBERT S. WALKER*
*Ranking Republican Member*

*ROBERT A. ROE*
*Chairman*

*WR/Teg*

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

MAR 22 1989

MAR 28 1989

Honorable James C. Wright, Jr.
Speaker of the House of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

In accordance with the Omnibus Trade Act of 1988 (P.L. 100-418) requirements, I am pleased to forward the plan to implement the Commerce Science and Technology (COMSCI) Fellowship program. With Congressional concurrence the Fellowship program would be implemented March 31, 1989.

The COMSCI program will provide a select group of Executive branch employees with the opportunity to learn how the Legislative branch and other Executive branch agencies function through work experiences of up to one year.

The program is designed to provide the Fellows with the opportunities in the following areas:

- Developing and using technology to promote economic development and growth;
- Identifying problems and opportunities affecting U.S. commercial innovation, quality, productivity and competitiveness;
- Identifying legal, regulatory and other policies and provisions that adversely affect commercialization of science and technology;
- Proposing changes in regulations and policies to improve industrial competitiveness;
- Recommending priorities for Federal R&D spending;
- Proposing methods for collecting, developing or exchanging foreign and domestic scientific and technological literature, data and information;
- Relaying advice from other agencies to the Under Secretary for Technology.

Sincerely,

Secretary of Commerce

# COMMERCE, SCIENCE, AND TECHNOLOGY FELLOWSHIP PROGRAM (COMSCI)

## A. LEGAL REQUIREMENT

FELLOWSHIP PROGRAM--There is established within the Department of Commerce a Commerce, Science, and Technology Fellowship Program with the stated purpose of providing a select group of employees of the executive branch of the Government with the opportunity of learning how the legislative branch and other parts of the executive branch function through work experiences of up to one year. The Secretary of Commerce shall report to the Congress within six months after the date of enactment of this Act on the Department of Commerce's plans for implementing such Program by March 31, 1989. (Omnibus Trade and Competitiveness Act of 1988, P.L. 100-418, Sec. 5163 (d))

## B. REPORT TO CONGRESS ON IMPLEMENTATION PLANS

By the Secretary no later than February 23, 1989.

## C. PROGRAM IMPLEMENTATION DEADLINE

March 31, 1989.

## D. PROGRAM OBJECTIVES

1. Develop a select group of executive branch employees and increase their value to their agencies by giving them an opportunity to learn how the legislative branch and other parts of the executive branch function, through a three-week COMSCI Seminar, field trips, and a COMSCI work assignment in another organization of up to one year.

2. Give the Fellows work experiences that will prepare them to serve as technology advisers to the Secretary, Under Secretary, for Technology and others, while suggesting ways to promote Federal technology transfer and commercialization and increase U.S. productivity and competitiveness.

## E. IMPLEMENTATION OBJECTIVES

1. Establish quality assignments first, then invite nominations of quality candidates. This should be a positive program of high benefit to the Office of the Under Secretary, the COMSCI Fellows, and the parent agencies.

2. Link the COMSCI Program with general Commerce technology objectives by:

   a. nominating Fellows and selecting assignments with a view to furthering the goals of:

      - o developing and promoting Federal policies and programs to increase U.S. commercial and industrial innovation, productivity, and growth;
      - o reducing barriers to competitiveness;
      - o developing policies and strategies for commerce, science and technology agreements and forums;
      - o making the Department of Commerce a focal point for Federal technology policy.

   b. developing Fellows as staff resources to their parent agencies, the Under Secretary, and others on technology transfer, productivity, and competitiveness.

   c. making COMSCI objectives with the objectives of the Federal Laboratory Consortium and the Interagency Committee for Federal Laboratory Technology Transfer.

3. Use the Federal Laboratory Consortium (described in Attachment 1) and the Interagency Committee for Federal Laboratory Technology Transfer (described in Attachment 2) as links between the Office of the Under Secretary and the executive branch agencies for:

   a. promoting the COMSCI Program.

   b. creating assignments in the member agencies for Fellows.

   c. channeling nominations from the member agencies to the Office of the Under Secretary.

   d. reviewing and applying the recommendations of Fellows.

F. ASSIGNMENT OBJECTIVES

Fellows will work with executive branch or legislative branch organizations in assignments that:

1. Prepare the Fellows to provide assistance to the Secretary and Under Secretary.
2. Broaden the professionalism, policy-formulation ability, and managerial experience of the Fellows.

3. Make the Fellows more aware of developing national and international issues in science, engineering, technology, technology commercialization, industrial productivity, and competitiveness.

4. Provide potential for Fellows to:

   a. discover opportunities for developing and using technology to promote economic growth and development.

   b. identify problems and opportunities affecting U.S. commercial innovation, quality, productivity, and competitiveness.

   c. identify legal, regulatory, and other policies and provisions that adversely affect commercialization of science and technology.

   d. propose changes in regulations and law to improve industrial competitiveness.

   e. recommend priorities for overall Federal R&D funding.

   f. propose initiatives for strengthening the efficiency and commercial relevance of aggregate Federal investment in research and development, including the Federal laboratory system;

   g. propose methods for collecting, developing, or exchanging foreign and domestic scientific and technological literature, data, and information.

   h. propose initiatives for strengthening technology-based learning systems, worker reeducation programs, and the application of modern management practices in technology-based business.

   i. relay advice from other agencies to the Office of the Under Secretary.

5. Prepare the Fellows to write COMSCI Yearbook papers that document the above accomplishments, proposals, and recommendations.

G. SEMINARS

Each annual program will begin with a three-week seminar and end with a one-week seminar. Periodic one-day or half-day seminars may be scheduled during the program.

FIRST WEEK:

Speakers from the Department of Commerce and other agencies, including the Secretary, the Deputy Secretary, the Under Secretary for Technology, and the Under Secretary's key staff.

SECOND WEEK:

Members of Congress and key staff from relevant committees.

THIRD WEEK:

Contracted or in-house training (emphasizing objectives 3 & 4).

Additionally, the Fellows will take part in a mid-assignment seminar to be held in January or February.

OBJECTIVES OF FIRST THREE WEEKS:

1. Inform Fellows of program objectives and their role in advancing the technology goals of the Department.

2. Introduce Fellows to key figures in technology policy area.

3. Make Fellows more aware of national and international issues in science, engineering, technology, technological innovation, technology transfer and commercialization, industrial productivity, and international competitiveness; more knowledgeable of the impact of these elements on the nation's economy; and more familiar with the variety of viewpoints and interests concerning these issues.

4. Make the Fellows more familiar with the economics, social and political issues, processes, and selection factors involved in funding science and technology programs.

5. Make the Fellows more aware of national long-range planning, educational, and workforce issues in technological growth.

6. Give Fellows a better understanding of how the executive and legislative branches are organized to develop and carry out national technology policies.

FINAL WEEK:

1. Provide a forum for feedback from Fellows to Secretary, Deputy Secretary, Deputy Secretary's staff and the Under Secretary for Technology.

2. Meet with the Federal Laboratory Consortium and the Interagency Committee for Federal Laboratory Technology Transfer.

3. Produce a COMSCI YEARBOOK for distribution in government, academia, and the private sector.

SEMINAR FACILITATOR:

Options:

a. member of staff of DoC Assistant Secretary for Administration.

b. member of staff of Under Secretary for Technology.

c. under contract.

H. FIELD TRIPS

From time to time the Fellows will visit scientific facilities, industrial complexes, and institutions to gain first-hand knowledge of how they function, their roles in the national technology community, and the views of their staffs.

I. COMSCI YEARBOOK

A COMSCI YEARBOOK will be published each year containing:

1. Final papers produced by the Fellows in accordance with sections F 4 & 5 above.

2. Selected papers volunteered by COMSCI alumni.

3. Issue papers developed by the Office of the Under Secretary.

4. Invited papers form distinguished scholars.

5. Assignments for the following year.

J. ESTABLISHING ASSIGNMENTS

The goal each year will be to establish 15-20 COMSCI assignments.

1. The Office of the Under Secretary for Technology will establish at least two assignments.

2. Other DoC organizations will be asked to offer assignments.

3. Each member-agency of the Federal Laboratory Consortium and the Interagency Committee for Federal Laboratory Technology Transfer will be asked to propose one or more assignments in that agency.

4. Relevant Congressional committees will be asked to offer up to four assignments.

5. The Executive Office of the President will be asked to offer one assignment.

6. Assignments will be established by March 1 each year, in preparation for announcing the COMSCI program and available assignments by March 31.

7. The Under Secretary will approve only those assignments that:

   a. are relevant to the commerce, science, and technology goals of the Department of Commerce;

   b. have high potential benefit for the Office of the Under Secretary; or for eligible parent organizations and their COMSCI-eligible key employees.

K. ELIGIBILITY

1. GS/GM-14 or above.

2. Full-time-permanent career employee of the executive branch.

3. Demonstrated ability to assume increasingly difficult responsibilities and perform increasingly complex assignments.

L. NOMINATION PROCEDURES

1. The Office of the Under Secretary will develop a nomination form for the Program.

2. Each year, the Office will invite nominations from the heads of DoC operating units and the member-agencies of the Federal Laboratory Consortium and the Interagency Committee for Federal Laboratory Technology Transfer.

3. Nominations will be due to the Office by June 1 of each year; selections will be announced by June 30 for the Program beginning the following September.

M. CLASS CHARACTERISTICS

If there are more candidates than available assignments, the candidates selected will be those who as a group offer the best combination of high qualifications and broad representation of experience and education, and who occupy permanent positions that have the highest potential to benefit from the assignments.

N. CLASS SCHEDULE

1. Each Fellows program will run between nine months and one year.

2. The formal program will run from the first seminar in September to the final seminar in June.

3. The mid-assignment seminar will take place in January or February.

4. From the final seminar in June until the end of the one-year period in September, Fellows will be available to the Under Secretary for continued consulting or for special projects, as determined by the Under Secretary.

5. If not called upon by the Under Secretary after the final seminar, Fellows may return to their parent organizations or, with the agreement of both the parent organization and the assignment organization, continue in their assignments until the end of the one-year period in September.

O. PROGRAM DIRECTION

The position of "Special Programs Director" will be established under the Executive Director for Management Services in the Office of the Under Secretary. The responsibilities of the Special Programs Director will include COMSCI direction.

P. FUNDING

1. The parent organization of a Fellow will pay for the Fellow's salary, benefits, travel and material fees related to seminars conducted under the auspices of the Under Secretary for Technology.

2. To the extent that funds are available, the Office of the Under Secretary will pay the expenses of running the seminars.

Q. POST-PROGRAM ASSIGNMENTS

Parent organizations will be expected to return Fellows to their previous assignments or to new assignments that make use of the Fellows' COMSCI training and experience. The importance placed on this re-entry is consistent with the emphasis on nominating high-quality performers who can benefit their agencies through their COMSCI experiences.

ATTACHMENT 1

FEDERAL LABORATORY CONSORTIUM

The Federal Laboratory Consortium (FLC) will have an important role in linking the objectives of the COMSCI Program with the technology objectives of the agencies, and in facilitating the creation of quality COMSCI assignments in the agencies.

> The need for more effective use of federally developed technology led to the establishment in 1974 of the Federal Laboratory Consortium (FLC). Today, nearly 400 laboratories and centers representing 11 agencies are members of the FLC.
>
> . . .
>
> The FLC is a service organization providing a basic link between the individual laboratory members and the potential users of government developed technologies. The FLC also assists this linkage through the development and support of various technology transfer methods. The backbone of the FLC is the individual laboratory or center representative. These individuals, in addition to representing their own laboratory, maintain contact with other government and private agencies, and research institutions, thus forming a national network of people dedicated to the process of technology transfer.
>
> . . .
>
> The FLC network of technology transfer laboratory representatives is most effective when requests identify a specific problem or need and personal contact is required. Topics of interest brokered through this network include new and modified technologies, processes or technical assistance.
> [FLC '87: The Competitive Edge (Fresno, California: DelaBarre & Associates, 1987), p. 1]

LEADERSHIP

FLC Chairman: Dr. Eugene Stark, Los Alamos National Laboratory.

FLC Administrator: Mr. Del M. DelaBarre, Fresno, California.

Mid Atlantic Regional Coordinator: Mr. Clifford E. Lanham, Army Harry Diamond Laboratories.

KEY REPRESENTATIVES

Department of Commerce: Mr. Joseph P. Allen

NIST: Mr. James Wyckoff

Agricultural Research Service: Mr. James Hall

Air Force: Mr. Walter R. Blados

Army: Mr Clifford E. Lanham

Navy: Dr. David L. Woods

Bureau of Mines: Dr. Donald E. Ralston

EPA Engineering Laboratories: Mr. Michael Mastracci

Forest Service: Mr. Allen Schacht

NASA Headquarters: Mr. Len Ault

National Institute of Health: Dr. Philip Chen

Strategic Defense Initiatives
Organization: Mr. Nick Montanarelli

U.S. Geological Survey: Dr. Ethan T. Smith

ATTACHMENT 2

INTERAGENCY COMMITTEE FOR
FEDERAL LABORATORY TECHNOLOGY TRANSFER

The Interagency Committee for Federal Laboratory Technology Transfer was established to assist in implementing Section 5 of the Federal Technology Transfer Act of 1986 (P.L. 99-502), which authorizes the Secretary of Commerce to:

1. make available to interested agencies the expertise of the Department of Commerce regarding the commercial potential of inventions and methods and options for commercialization which are available to the Federal laboratories, including research and development limited partnerships;

2. develop and disseminate to appropriate agency and laboratory personnel model provisions for use on a voluntary basis in cooperative research and development arrangements; and

3. furnish advice and assistance, upon request, to Federal agencies concerning their cooperative research and development programs and projects.

The following page lists the current membership ,by Position Title, of the Interagency Committee.

INTERAGENCY COMMITTEE ON FEDERAL LABORATORY TECHNOLOGY TRANSFER

| | |
|---|---|
| Executive Office of the President | Office of Science and Technology Policy; Science Advisor |
| United States Trade Representative | Assistant U.S. Trade Representative |
| Department of Commerce | Acting Assistant Secretary for Technology Policy |
| | Associate Under Secretary for Economic Affairs |
| Department of Agriculture | Assistant Secretary for Science and Education |
| Department of Interior | Assistant Secretary for Water and Science |
| Environmental Protection Agency | Assistant Administrator for Research and Development |
| Department of Defense | Deputy Under Secretary for Research and Advanced Technology |
| | Assistant Secretary of the Air Force for Acquisition |
| | Assistant Secretary for Research, Development and Acquisition |
| | Assistant Secretary for Research, Engineering and Systems |
| National Aeronautics and Space Administration | Deputy Associate Administrator, External Affairs |
| Department of Energy | Director, Office of Energy Research |
| Department of Transportation | Science and Technology Advisor to the Secretary of Transportation |
| Department of Health and Human | Deputy Under Secretary for Health and Human Services |
| | Deputy Assistant Secretary for Health Services |
| Veterans Administration | General Counsel |

PB89-166565/AS

# Annual Report to the Congress from The Secretary of Commerce on The National Technical Information Service: Operations, Audit, and Modernization

Required by

PL 100-418 and PL 100-519

January 1989

# National Technical Information Service

## Fiscal Year 1988 Annual Report

### I. Introduction

The National Technical Information Service (NTIS) is the central source for the public sale of technical reports, computer software, and data files, as well as the licensing of intellectual properties generated by and for the U.S. Government. This function is intended primarily to improve the efficiency and effectiveness of the U.S. research and development enterprise and help increase productivity and innovation in the United States.

NTIS operates under the provisions of Title 15, U.S. Code 1151-7, which directs that costs be recovered from fees paid by users of information products and services. Other legislation has, from time to time, been enacted which fine-tunes or emphasizes certain aspects of the NTIS mission. These laws include:

- Stevenson-Wydler Act (PL 96-480), as amended, which emphasizes NTIS' role as the central clearinghouse for the transfer of information on Federal technologies.

- Patent Rights in Inventions Made with Federal Assistance (part of PL 96-517) and the Federal Technology Transfer Act (PL 99-502) which authorize the management of a patent licensing and inventors incentive awards program.

- Japanese Technical Literature Act (PL 99-382) which authorizes NTIS to assist the Department of Commerce and the Japanese Technical Literature Office in improving the availability of Japanese scientific and technical literature in the United States.

- NIST Authorization Act for FY 1989 (PL 100-519) which was signed October 24, 1988. This Act created the new Technology Administration headed by an Under Secretary for Technology within the Department of Commerce to provide a greater focus on technology and competitiveness within the Department and provide for more effective management of these responsibilities. It also provides for stronger representation for industry in discussions of technology issues both here and abroad. NTIS is a vital part of this new Administration.

At NTIS, more appropriate authority has been needed to build strategic alliances, to invest in the latest technologies, and to manage its human resources. Three provisions of the NIST Authorization Act are especially helpful in achieving the foregoing goals:

- Flexible use of contracts, grants, or cooperative agreements with the private sector, individuals, firms or other organizations,
- Acquisition by NTIS of capital equipment and inventories from receipts for work or services performed or to be performed, and
- Authorization to employ personnel as necessary without regard to personnel ceilings.

The NIST Authorization Act requires an annual report summarizing operations of the preceding year and providing (a) an operating plan for the upcoming year, (b) details of modernization progress, (c) long term modernization plans, and (d) results of the most recent annual audit.

- The Omnibus Trade and Competitiveness Act (PL 100-418), which was signed August 23, 1988, provides for the Secretary of Commerce to report the Secretary's recommendations for improvements in NTIS (including methods for automating document distribution and inventory control) and any statutory changes required to make those improvements to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives by January 31, 1989. The Trade Act also provides for NTIS to operate a Clearinghouse on Education and Training Materials for the Department of Education.

This report fulfills the Secretary's reporting requirements of both the Trade Act and the NIST Authorization Act.

## II. NTIS Operations—FY 1988 Accomplishments and FY 1989 Plans

In FY 1988, NTIS again remained self-supporting, with total revenues of $25 million earned from the sale of products and services to customers and client agencies and total costs of $24.9 million. Revenues are estimated at $25.3 million for FY 1989. Total receipts were $41.8 million in FY 1988 and are estimated at $47 million in FY 1989. Total receipts are sales revenues plus deposit account replenishments (customer advances to cover future purchases from NTIS), patent licensing royalties, and collections made for other agencies. Total obligations were $40.5 million in FY 1988 and are estimated at $47 million for FY 1989. These

obligation amounts include net other agency collections of $7.6 million returned to Treasury in FY 1988 and an estimated $8 million in FY 1989. Total NTIS costs were $25 million in FY 1988 and are estimated at $25.1 million in the FY 1989 financial plan prepared in August, 1988.

Operating results for FY 1988 were mixed, showing the continuing pattern of change taking place throughout the information industry. Reflecting an ongoing customer move away from paper bibliographic products toward greater use of online searching, unit sales of Abstract Newsletters, Published Searches, and the Government Reports Announcements and Index journal declined 10% from 1987, while earnings from the NTIS online database rose by a little more than 7%, exceeding $1.5 million for the first time. After a downward trend lasting several years, sales of full text reports stabilized at slightly under 1.8 million copies. Standing order sales dropped 12% while subscription sales saw a small 2% increase. Computer-based products, however, continued their strong growth pattern: unit sales of software diskettes and tapes were up 11%; data diskettes and tapes rose 19%, and earnings from other agency databases were up by more than 70%. On the acquisition side, more than 68,000 items were added to the NTIS collection, an increase of 8% over the 1987 input level.

Other significant accomplishments during 1988 include:

- Doubling the number of research summaries in the Federal Research in Progress Database over what they were a few years ago. They now number over 135,000, and the database is updated monthly rather than semi-annually. These summaries of ongoing research are used for R&D planning, potentially saving substantial R&D funds.

- Preparing, in support of the Department's Office of Japanese Technical Literature, the *1988 Directory of Japanese Technical Resources in the United States*, a listing of organizations in the United States that collect, abstract, or provide translation assistance to U.S. businessmen. The Directory also included a listing of all the known Japanese-to-English translations prepared by the U.S. Government. NTIS arranged for the translation of two Japanese technical reports as well as 7 particularly useful journal articles. Approximately 1,600 Japanese language reports were added to the database during the year.

- Establishing the Federal Computer Products Center--using extensive contacts within the government to increase the amount of software, numeric and text data files, and bibliographic databases that are offered.

- Renewing dissemination and acquisition agreements with over 160 organizations in 60 countries. NTIS also signed new agreements with five foreign information sources, and several additional agreements are in final stages of negotiation: One major new agreement with the Taiwan S&T Information Center is making their R&D reports easily accessible to the U.S.

research community for the first time. Agreements have been reached with Proudman in England, INFILE in Spain, and SINTEF in Norway. The U.S. Intelligence Community agreed to supply "open source" intelligence foreign documents. Also, NTIS reached an agreement under which NTIS and the Library of Congress will collect information about Japanese-to-English S&T translations performed in the U.S. They will be added to the International Translations Center Database in the U.S.

- Granting 66 licenses to U.S. firms on Government-owned inventions. Revenue from licensing was approximately $5.6 million, most of which is transferred to the various agencies.

- Initiating a program of joint ventures with private firms to assist in making results of U.S. Government R&D available to industry, business, and the general public. At the end of FY 1988, agreements with four firms were signed, and six others are in various stages of negotiation. Private partnerships such as these are greatly increasing market opportunities for the information industry by building on the NTIS collection.

Expense and staffing details for FY 1988 and FY 1989, by major NTIS activity, are shown on page 6. These major activities are:

**Office of the Director / Policy & Planning**
- Directs and is responsible for all activities of the organization. Develops, maintains and monitors implementation of long-range strategic plans.

**International Affairs**
- Negotiates and administers bilateral agreements with foreign and international organizations; identifies and acquires foreign technical information.

**Program & Product Management**
- Operates the domestic acquisitions program and the Federal Computer Products Center; develops new and improved NTIS products and services.

**Bibliographic and Document Services**
- Conducts cataloging, indexing, abstracting, filming, archiving, printing, order processing, warehousing, and distribution functions.

**Center for the Utilization of Federal Technology (CUFT)**

- Develops and disseminates special information products and services to facilitate transfer of Federally-owned or -originated technologies to state and local governments and to private industry; licenses government owned patents.

**Marketing & Customer Service**

- Conducts all functions relating to customer services, marketing/market development, promotion and sales.

**Administration**

- Provides support services relating to financial, administrative, and computer activities.

**National Technical Information Service**
**FY 1988/89 Annual Report**
**($ in Thousands)**

| Major NTIS Activity | Personnel Compensation | | Other Costs | | Total Costs | | Full Time Equivalent Employment | |
|---|---|---|---|---|---|---|---|---|
| | FY 1988 Actual | FY 1989 Plan | FY 1988 Actual | FY 1989 Plan | FY 1988 Actual | FY 1989 Plan | FY 1988 Actual | FY 1989 Plan |
| Office of the Director / Policy & Planning | $546 | $475 | $209 | $314 | $755 | $789 | 9 | 9 |
| International Affairs | 395 | 410 | 168 | 274 | 563 | 684 | 9 | 9 |
| Program & Product Management | 846 | 976 | 1,413 | 1,555 | 2,259 | 2,531 | 24 | 27 |
| Bibliographic and Document Services 1/ | 3,423 | 3,537 | 6,412 | 5,593 | 9,835 | 9,130 | 139 | 145 |
| Center for Utilization of Federal Technology (CUFT) | 494 | 620 | 425 | 752 | 919 | 1,372 | 13 | 16 |
| Marketing & Customer Service 1/ | 1,258 | 1,216 | 789 | 800 | 2,047 | 2,016 | 46 | 45 |
| Administration 2/ | 3,046 | 3,198 | 5,578 | 5,382 | 8,624 | 8,580 | 86 | 102 |
| Total, NTIS | $10,008 | $10,432 | $14,994 | $14,670 | $25,002 | $25,102 | 336 | 362 |

1 / Other costs for Bib. & Doc. Services and Marketing & Customer Service include payments to the Department of Commerce and the Government Printing Office totaling $3.6 million in FY 1988 and $3.8 million in FY 1989 for printing services.

2 / Other costs for Administration include the following reimbursements to the Department for services provided:

| | FY '88 Actual (000's) | FY '89 Plan (000's) |
|---|---|---|
| Computer Support | $1,366 | $1,290 |
| Personnel: | 459 | 449 |
| Procurement: | 65 | 62 |
| General Counsel: | 133 | 132 |
| Miscellaneous Working Capital Fund Costs: | 132 | 131 |

**NOTE:**

Regarding cost comparisons between FY 1988 and FY 1989: Beginning in FY 1989, NTIS will no longer be involved in a joint distribution program with the Department of Energy's (DOE) Office of Scientific & Technical Information (OSTI) in Oak Ridge, Tennessee. NTIS had been the sales and distribution outlet for the full range of OSTI's non-classified information products and services, including both public & DOE customers. Beginning in FY 1989, NTIS will be the sales and distribution outlet for public sales only, therefore a reduction of approximately $1 million in costs is included.

1/19/89

## III. Results of the Most Recent Annual Audit

Section 212(d) of the National Institute of Standards and Technology Authorization Act for Fiscal Year 1989 provides that:

> "The Secretary of Commerce shall provide for annual independent audits of the Service's [the National Technical Information Service] financial statements beginning with fiscal year 1988, to be conducted in accordance with generally accepted accounting principles."

Section 212(f)(3)(E) provides that the Secretary will submit an annual report which shall "include the results of the most recent annual audit carried out under subsection (d)."

NTIS has never before engaged in an independent audit of its financial statements. Shortly after enactment of the NIST authorization legislation, NTIS consulted with staff of the General Accounting Office to determine how best to implement this audit requirement. The GAO advice was (1) that any initial audit of NTIS' financial statements would require an extensive, preliminary review of NTIS' financial systems and practices, and (2) that in order to conduct such a review and audit for FY 1988, NTIS would have had to have the auditors on-site during the early summer of calendar 1988, some three months before the NIST authorization legislation was enacted.

In order to comply as fully as possible with the intent of the NIST authorization legislation, NTIS has developed the attached, unaudited financial statements. NTIS has also prepared a description of the work to be done by the independent auditors. This description was submitted to GAO staff for their comments and guidance, and NTIS is working with the Commerce Office of Inspector General to arrange for this work to be done. The plan is to have the auditors on site by June 1989, and to include the results of their audit in the NTIS annual report to be sent to Congress early in 1990.

NATIONAL TECHNICAL INFORMATION SERVICE
BALANCE SHEET
TRUST FUND (13X8546)
As of September 30, 1986 through 1988

UNAUDITED

| ASSETS | 1988 | 1987 | 1986 |
|---|---|---|---|
| Current Assets | | | |
| Fund Balances with U.S Treasury | $15,938,452 | $17,367,426 | $11,373,985 |
| Imprest Funds | 2,500 | 2,500 | 2,500 |
| Accounts Receivable and Advances (Net) | 5,368,333 | 4,241,470 | 3,372,639 |
| Finished Goods Inventory (Net) | 3,987,882 | 4,352,148 | 5,144,296 |
| Total Current Assets | $25,297,167 | $25,963,544 | $19,893,420 |
| Fixed Assets: | | | |
| Personal Property and Equipment | 879,879 | 708,051 | 621,946 |
| TOTAL ASSETS: | $26,177,046 | $26,671,595 | $20,515,366 |
| LIABILITIES AND EQUITY of the U.S. GOVERNMENT | | | |
| LIABILITIES: | | | |
| Current Liabilities | 15,544,678 | 15,615,540 | 8,234,032 |
| Other Liabilities | 8,149,727 | 8,553,917 | 9,076,123 |
| Total Liabilities | $23,694,405 | $24,169,457 | $17,310,155 |
| EQUITY OF THE US GOVERNMENT | | | |
| Unexpended Budget Authority: | | | |
| Unobligated | 5,265,569 | 3,948,006 | 3,460,274 |
| Undelivered | 733,146 | 351,250 | 326,783 |
| Total Unexpended Budget Authority | $5,998,715 | $4,299,256 | $3,787,057 |
| Invested Capital | -7,236,770 | -5,154,664 | -3,669,966 |
| Retained Earnings | 3,720,696 | 3,357,546 | 3,088,120 |
| Total Investment and Retained Earnings | -$3,516,074 | -$1,797,118 | -$581,846 |
| Total Equity | $2,482,641 | $2,502,138 | $3,205,211 |
| TOTAL LIABILITIES AND EQUITY OF THE US GOVERNMENT: | $26,177,047 | $26,671,595 | $20,515,366 |

NATIONAL TECHNICAL INFORMATION SERVICE — UNAUDITED
INCOME STATEMENT
TRUST FUND (13X8546)
For the Period Ended September 30, 1986 through 1988

| | 1988 | 1987 | 1986 |
|---|---|---|---|
| NET SALES | $25,033,643 | $22,085,959 | $22,381,705 |
| Cost of Sales | 24,943,248 | 22,141,949 | 21,613,199 |
| Interest Expense | 739 | 152 | 824 |
| | $24,943,987 | $22,142,101 | $21,614,023 |
| EARNINGS (LOSS) from Continuing Operations before Extraordinary gain | 89,656 | (56,142) | 767,682 |
| EXTRAORDINARY GAIN | 0 | 260,000 * | 0 |
| EARNINGS (LOSS) Including Extraordinary Items | $89,656 | $203,858 | $767,682 |

* An extrordinary gain in the amount of $260,000 was realized during fiscal year 1987 for the write-off of inactive deposit accounts. Based on subsequent guidance from the Department, the Deposit Accounts were reopened in fiscal year 1988. Before transferring funds to Treasury, we will make one more special attempt to contact the customers involved. If we cannot contact them or if the customers do not want us either to return the money or keep the account open for future use, the funds will be transferred to Treasury and deposited in the "Forfeitures of Unclaimed Money and Property" fund.

## IV. Long-Range Plan for Improvements and Modernization

This plan records the current vision for improving and modernizing the information products and services NTIS provides. Because the ease with which information can be spread is critical to the rate at which innovation and change can occur, NTIS must become a highly automated operation within the next few years to continue offering high quality support to American business, industry, academia, and government. Technological advances including lower cost telecommunications, increased computer speeds, and higher storage capacity will permit economical full-text storage, search, and retrieval to be available from anyone's desktop. NTIS intends to exploit the best available technologies as they emerge in order to dramatically improve delivery—including to the desktop— of technical information so essential to America's economic well-being.

Futurists have been predicting for some time that by the year 2000, America will be a post-industrial information society in which services play a larger role in the economy than do products. An important part of this service growth will concern itself with reducing the "information float," i.e., the time elapsed from the creation to receipt of information. There will be a dramatic surge in the proportion of workers creating, processing, and distributing information—the Age of Information.

The following facts indicate that we are already well on the way to this new age:

- Some 7000 scientific articles are written daily.
- Scientific and technical information volume increases 13% annually (doubling every 5.5 years).
- Increase of annual S&T information volume could jump to 40% (doubling every 20 months).

Three key points should be emphasized:

- Twenty-five percent of U.S. GNP is produced in the primary information sector.
- If users are made aware of potentially useful information, they will pay for it.
- Emphasis is shifting from supply to improving selection. With the vast amounts of information rapidly becoming available, users are becoming inundated, creating a need for "information gatekeepers." Custom-

designed information products for individual users (so-called mass customization) are the wave of the future.

## Office of Technology Assessment Report

The Congressional Office of Technology Assessment (OTA) in its October 1988 report, "Informing the Nation—Federal Information Dissemination in an Electronic Age," contains some sobering views regarding NTIS during recent years. A few excerpts are in order to help put this plan in its proper context.

> *"NTIS operates in a highly constrained environment, characterized by ambivalent support from the executive branch, limited financial resources, mixed support from the information industry, limited technical resources, and a difficult product mix (many low volume items)."*
>
> *"... NTIS has a voluntary relationship with the source agencies and cannot require agencies to submit materials."*
>
> *"Sales of all major NTIS products have declined markedly since 1980, in most cases by about 50 percent."*
>
> *"Fortunately, technological advances have created several possibilities that appear to be ideally suited to the nature of NTIS demand."*
>
> *"An electronic NTIS with a more complete and up-to-date archive would open up a wide range of possibilities for marketing and dissemination of scientific and technical information."*

These views provide the basis for OTA's recommendations regarding increased use by NTIS of electronic information systems as well as increased NTIS and Superintendent of Documents cooperation. The following sections specify our goals and provide further background on them and on our strategies as well as our first steps towards modernization.

## NTIS Long-Range Goals

The following NTIS goals support the basic Departmental mission to enhance the U.S. position in world commerce.

**1. Increase the nation's competitiveness and stimulate productivity and economic growth by strengthening our position in the worldwide technical information community.**

Maintaining our national competitiveness demands that the Federal Government pursue a more aggressive role in acquiring and disseminating technical information in all formats, especially electronic ones. Thus, NTIS works to lead other agencies as well as state and local governments toward better strategic use by their user communities of the technical information they generate. NTIS aims to attract and retain a loyal group of customers through a unique combination of product, distribution, promotion, and price factors. NTIS believes that users of government information deserve the very best products and services that can be provided.

One new initiative is to increase the number of joint ventures with private information enterprises so that particular market niches will be well served. Such alliances draw on each other's strengths to improve access, timeliness, quality, and ease-of-use of government information. Joint ventures meet four important criteria:

- Improve NTIS' ability to disseminate scientific and technical information.
- Create a product or service which gives added value to the information user.
- Generate additional revenue for NTIS.
- Create a market/profit opportunity for a private firm.

A second important strategy calls for modernizing systems and equipment to provide users with high quality products and services. Replacing outdated equipment with modern technology will allow NTIS to improve both the products themselves and their speed of delivery.

**2. Collect and archive government-sponsored scientific and technical information and position that information in the U.S. economy.**

Strategies for accomplishing this goal include increasing the number and improving the quality of outreach programs targeted to agency heads and other



98-198 0 - 89 - 24

key leaders. This is crucial in attracting new sources of technical information, increasing the quantity of material acquired from current sources, and improving technical assistance to both new and current source organizations.

Through participation in private user groups, professional information community activities and trade shows, by publishing articles, by organizing seminars on technology transfer, and through direct contacts with agency heads, NTIS will increase federal recognition of the value of government information to the economy. NTIS plans to expand its Library Liaison Network of users by 5% each year to provide an interactive channel of communication to the local level. Programs to create and nurture partnerships with business, academic, and public libraries are being developed.

NTIS is evaluating and preparing work statements to contract out the functions of the Promotion Division, as specifically authorized by Public Law 100-519. By contracting out this activity to one or more advertising, promotion, and direct marketing firms, NTIS anticipates that new and innovative promotional techniques will increase the sales of the various information products and services.

NTIS also intends to continue exploring ways to expand its cooperation with the Superintendent of Documents (SupDocs), concentrating on the areas mentioned in the OTA report. As a first step, discussions are currently taking place for NTIS to assist in disseminating SupDocs publications.

**3. Enrich the U.S. technology base by increasing the inflow of foreign technical information, especially that of Japanese origin.**

One major strategy here is to establish NTIS as the prime source for unpublished foreign technical report literature. This includes supporting the policy activities of the Department's Office of Japanese Technical Literature by publishing numerous reports that summarize the current status of Japanese research and development in key high technology fields. In addition, NTIS will continue to update the annual *Directory of Japanese Technical Resources in the United States*. This directory provides information on commercial services, government programs, and libraries that collect, abstract, translate, or disseminate Japanese technical information as well as citations of Japanese technical documents translated at government expense in the preceding year. NTIS also negotiates with many foreign government agencies to produce formal agreements for sharing information.

Another strategy is technology monitoring. NTIS is a partner in Project STRIDE which, in response to Executive Order 12591, uses science counselors in U.S. embassies abroad to gather data on the latest scientific developments and cable it to the State Department from where it is shared with NTIS and NSF for evaluation and dissemination. The STRIDE effort provides convincing evidence that the

foreign service S&T reporting function needs to be strengthened. It is evident that S&T developments of high interest to the U.S. community are taking place overseas. Yet, unlike other industrialized countries, the U.S. has had no coordinated and effective method for collecting, evaluating, and distributing information about these developments. NTIS objectives call for:

- Mounting an effort to gain support for improving the reporting functions of embassy S&T offices or the establishment of a government or quasi-government organization, with field offices in key countries, having the sole function of feeding information about foreign technical developments back to U.S. industry.

- Making available the knowledge contained in the trip reports of visiting experts sponsored by U.S. agencies. Distributing the reports themselves would seem to be out of the question; however, consideration should be given to extracting the valuable information content from the reports and making that available.

- Expanding publication of the resulting STRIDE material. This may involve a series of newsletters separate from the existing series of abstract newsletters.

Other innovative approaches such as computer-aided translation, executive-level seminars for U.S. business people, co-sponsoring international symposia on Japanese literature for technology and commerce, and making Japanese databases available for searching online in the U.S., are also required. Additional key tasks include working with CENDI* (the International STI Working Group) to coordinate our foreign acquisition efforts and to support private interest groups dealing with foreign technical information.

* CENDI refers to the Commerce, Energy, NASA, NLM, and Defense Information Group, an interagency organization whose purpose is to provide an organized program to improve the productivity of Federal R&D efforts. NTIS is the Department of Commerce representative on CENDI.

**4. Announce and disseminate the widest range of technical information—including computer processable data—to the widest possible U.S. audience by determining current market needs and anticipating user needs.**

Increased reliance on the private sector and use of new technologies are NTIS' basic strategies for improved outreach. Modernization calls for increased use of microcomputers, linked through groups of local area networks, which are, in turn, linked to the mainframe. Additional enhancements to the automated telephone system, employing bar coding for inventory and order system applications, and

moving into computer-assisted indexing and translation as these technologies develop are also included in the NTIS long-range plan. New microfiche blowback and optical storage, retrieval, and dissemination systems are actively being pursued (see the following sections).

**5. Improve the collection, dissemination, and licensing of federally-owned patents and the transfer of other specialized technologies having potential application in state and local governments and private industry.**

The NTIS Center for the Utilization of Federal Technology (CUFT) promotes the development and application of technology in U.S. business and industry by identifying, publicizing, and licensing federal inventions. Exclusive patent licenses for federal technology provide powerful economic incentives for significant research and development commitments to bring projects to market. To date, these commitments have totalled over $600 million. Foreign patents, obtained and licensed, provide protection against foreign competitors for $80 million annually of U.S. exports. In coming years, NTIS will be responding vigorously to requests for support from private and federal licensing centers.

## Electronic Dissemination

Electronic dissemination of information is rapidly overtaking the more traditional media of paper and microfiche as the vehicle of choice for many users. Therefore, NTIS will make electronic dissemination a major focus over the next few years. In doing so, NTIS must become more knowledgeable about who its end-users are and what kinds of information products they need. NTIS has traditionally placed great emphasis on involvement with intermediaries in the library community. Such involvement will continue even as end-users increase their use of personal computers to locate the information they need by themselves. This direct user involvement will increase dramatically in the next few years.

Plans call for expanding products to take advantage of the opportunities provided by new dissemination technologies in order to serve its users more efficiently. New offerings will include such items as:

- CD-ROM for vertical slices of the NTIS Bibliographic Database, agency regulations with accompanying full text search and retrieval software, and popular data files. NTIS already makes portions of the Database available on CD-ROM through three private sector vendors.

- CD-ROM to begin offering full-text information.

- Diskettes for selected databases or subsets of databases, abstract newsletters containing extracts from the NTIS Bibliographic Database, and Selected Research in Microfiche (SRIM) indices.

- Direct computer-to-computer transfer of bibliographic data files and software in computer-processable format as well as standing orders and subscriptions.

- Facsimile order fulfillment for customers who need documents on a rush basis.

- Electronic bulletin boards for disseminating time-sensitive agency material to the public as well as providing near instantaneous announcements of new offerings.

- Extremely time-sensitive information will be transmitted via state-of-the-art technology. NTIS is currently involved in discussions of a confidential nature about such arrangements with a potential joint venture partner.

It is possible that NTIS could provide CD-ROM production services to other agencies to make it easier for them to provide access via CD-ROM. Another possibility is participation in the FedROM Project of SIGCAT, the Special Interest Group on CD-ROM Applications and Technology. The idea behind FedROM is that an agency with a useful database that is too small to put on a separate compact disk could put the database on a disk along with small databases from other agencies.

NTIS' Federal Computer Products Center will greatly expand offerings of computer-readable products generated by the U.S. Government. Using extensive contacts within various federal agencies, the Center will increase acquisitions of new and updated computer software, numeric and text data files, and bibliographic databases. A primary objective is to have computer-based training aids available on PC diskettes and CD-ROMs.

## Electronic Modernization Strategies

The NIST Authorization Act states that NTIS may "retain and, subject to appropriations acts, utilize its net revenues to the extent necessary to implement the plan submitted... ." Using these revenues, the following strategies call for employing the "best available technology" to achieve the given objectives. Of course this plan cannot be static; it must be regularly reviewed for accuracy and performance, modified in light of experience, and constantly questioned as to the current validity of its assumptions.

*Objective: Increase Quantity and Quality of Products and Services*

**1. Utilize computer-assisted translation systems.**

The U.S. urgently needs to expedite the use of machine translation by scientists and technicians who want quick assessments of the technical content of foreign literature without going through the costly, laborious process of full translation. NTIS intends to seek a joint venture with a private sector partner to utilize a production computer-assisted translation system, especially one capable of translating from Japanese to English. Current U.S. Government efforts to develop Japanese-to-English translation systems are limited to a project sponsored by the Air Force Foreign Technology Division and the intelligence community.

**2. Standardize input formats.**

NTIS currently receives over two-thirds of the bibliographic citations needed to input information into the collection in computer-readable form. NTIS processes the remaining 16,000 or so by entering the necessary data elements into its computer system. Plans call for providing source agencies with software to input their material to NTIS in a standardized electronic form. A working group has been established with NTIS' major contributors to begin defining standards in this area. The first task of the group is to look at electronic publishing standards. The agencies involved are NASA, DoD, Energy, and the National Library of Medicine.

**3. Acquire a minicomputer for electronic transmission.**

Customers would benefit from NTIS having the capability to electronically receive and transmit files, databases, and software as well as copy computer tapes for which there are orders. Acquiring a minicomputer for these purposes would speed NTIS response time to customer needs for these products.

*Objective: Decrease Costs and/or Improve Operations*

**4. Acquire computer-assisted fiche cameras and film processing equipment.**

NTIS, through the Office of Publications, plans to acquire two state-of-the-art, computer-assisted microfiche cameras. Special features of the cameras are:

- Automatic page feeding that increases document throughput and operator production rates.

- Integrated titling utilizing input via magnetic tape or hard disk technology and a bar code system that provides computer-assisted retrieval of randomly filmed documents in seconds.

The first camera will be installed in July 1989. In addition, new film processing equipment will be installed.

**5. Acquire bar coding equipment for inventory control.**

NTIS is investigating the use of bar coding technology to improve operations and service to its customers. Several possible applications will be reviewed to determine their feasibility and efficiency. They are:

- Archival control, which would eliminate manual logs to control archive copies routed outside the archive area.

- Bulk storage location control, which would eliminate transposition errors in location numbers which result in lost stock.

- Random filing of shelf stock, which would minimize the chance of misplaced stock and would result in more efficient utilization of stock space.

- New stock control, which would improve throughput of new documents and result in better control of physical inventories in response to yearly audit and inventory control requirements.

- Shipping, which would permit automated preparation of invoices, logs, and so forth to trace shipments and provide information on customer inquiries. NTIS is currently using bar coding in this area for one packaging service to control shipments sent via this company.

In order to derive all of the potential benefits of this technology, a Bar Coding Task Force has been created with representatives from each NTIS functional area to explore all possible applications and to ensure coordinated implementation of this technology. This group will evaluate vendor hardware and capabilities and prepare samples or acquire equipment to test their claims. A phased implementation plan is targeted for the Third Quarter of FY 1989 with initial start-up in FY 1990. Complete phase-in of bar coding applications is anticipated within four years.

*Objective: Increase Product Sales*

**6. Achieve full-text optical storage and dissemination systems.**

Ultimately, NTIS intends to create a total electronic document system. A vital part of such a system is the capturing of the full text information. As a first step, NTIS is evaluating optical disk technology for application in document archiving and dissemination. The intent is twofold. First, mass storage of full-text documents on optical disks, perhaps utilizing the "jukebox" approach, would permit faster retrieval of documents for reproduction and fulfillment of NTIS document demand. One 12-inch disk can store approximately one billion characters—a gigabyte—of data, or roughly 500,000 pages of double-spaced typed material. Reproduction would be accomplished via laser printing on paper, microfiche, and optical disk for in-house fulfillment. A second benefit would be the ability to transmit the document electronically to the user via FAX. The advantages of such a system are faster availability and the transmission of full-text reports.

NTIS will develop the requirements for optical storage and dissemination systems in FY 1989. Consideration will be given to archivability as well as product quality and the cost of storage and output. Upon evaluation and acceptance of a proposal, a trial system would be procured. It is proposed to test the system on a controlled segment of newly input materials to evaluate performance, quality, and stability. If the test is successful and a cost/benefit analysis supports it, all newly acquired materials would be added. Areas of particular concern are those materials which present such problems as photographs, half-tones and the like. Initial tests should be completed in FY 1990. The timeframe for full implementation, which includes essential portions of the archive, is ten years.

**7. Acquire a front-end microcomputer for the Selective Research in Microfiche (SRIM) system.**

SRIM is a customized selective dissemination of information service which currently serves nearly 500 users. User profiles are established and processed on the mainframe. The user has the option of selecting full text reports based on subject categories, subject terms or other special criteria. The profiles are matched against new acquisitions twice each month. All documents matching the user's profile are sent to that user. The system hardware was designed and built by what was then the National Bureau of Standards in the late 1960's. The distribution is accomplished with a series of bins filled with microfiche for a given issue. Punch cards are produced which, when loaded into a static reader, cause lights to go on over each bin containing fiche which match a user's profile. A clerk then selects fiche from the bins for each customer. While this system provides the basic services required, it continues to be labor intensive. NTIS plans to upgrade the SRIM system with a front-end microcomputer, IBM PS/2, Model 70

or compatible. This will likely evolve into a system for selective dissemination of information via CD-ROM.

**8. Examine state-of-the-art electronic dissemination technologies as they emerge.**

The rapidly changing technology for disseminating information requires NTIS to examine its operations carefully to determine how to take advantage of these new opportunities. At a time when the United States is trying to maintain its industrial competitiveness in global markets, NTIS, as the government's major source of federal scientific and technical information, has a critical role in providing U.S. Government, academic and business interests with the tools to adapt to advancing technology in their fields.

A team, with membership from all affected offices, will act as a forum for considering new technologies on an ongoing basis. The team will identify electronic dissemination technology applicable to NTIS' mission and prepare scenarios describing alternate levels of involvement. For each scenario the team will discuss:

- technology required
- NTIS readiness to move into the new area
- estimated costs and revenues
- advantages
- disadvantages
- obstacles
- impact on customers
- opportunities for joint ventures with the private sector
- potential for coordinating activities with other federal entities
- effect of implementing new technology on existing NTIS policy, procedures, and organization
- description of tasks and resource requirements for each scenario, indicating the level of contractor involvement anticipated.

The team will prepare recommendations for consideration by NTIS' Executive Steering Committee. Recommendations that are accepted by the Director and Deputy Director will become part of NTIS' Strategic Plan. Since many of the recommendations are likely to require a feasibility study, implementation on a limited or test basis, or development of a prototype, the team will evaluate the results at each major milestone to determine if the technology is likely to meet expectations or if the project should be aborted.

Among the areas which will be evaluated are:

- satellite transmission

- use of CD-ROM for technical report dissemination, building on the lessons learned from the European ADONIS project
- merged online retrieval of government bibliographic and numeric databases.

It is estimated that some $5 million will be expended on the above mentioned improvements over the next several years.

## V. Modernization Progress

In seeking to improve and modernize its operations, NTIS took a number of significant steps in FY 1988.

### Service Delivery

Successful American businesses have long known that a major key to increasing sales lies in providing quality service to customers. To accomplish its governmental mission and to continue earning sales revenues sufficient to cover its costs, NTIS must also seek to improve the quality of the service it provides to customers as well as information sources. In FY 1988, the efforts made to improve and modernize service delivery include:

- Training of NTIS staff so that by being more familiar with products and services, they can provide better service to customers.
- Investing in a new telephone system which does two things: it evenly distributes incoming calls to the next available agent, and it provides data that enables managers to control resources more efficiently. Implementing phase one has resulted in NTIS being able to answer additional calls with a faster response time. This has been a major factor in a 28% increase in the number of calls being received with a corresponding increase in phone sales.
- Improving customer accounting systems, cutting the time to prepare statements and invoices by 66%.
- Providing employees with better tools—new computer terminals, PC's, and refurbished offices—to do the job on behalf of customers.
- Expanding the NTIS electronic ordering service, QuikSERVICE, with a module called QuikQUERY. This new module permits Deposit Account customers to dial up and check their account balances to avoid ordering delays caused by an overdrawn condition.

- Placing a renewed emphasis on the needs of NTIS customers by spending time and money in customer contacts to learn more about what services customers want. This included contacts with groups such as the Industrial Technical Information Managers Group, more conference exhibits, more travel, and library liaison efforts.

- Investing in diskette copying equipment to reduce order turnaround time.

- Investing in new two-sided electronic printer systems through the Department's Office of Publications.

**Products and Services**

- Establishing a number of joint ventures with private sector firms to improve information dissemination. One agreement calls for a firm to publish and market a directory on NTIS' inventory of training and related materials on CD-ROM and paper. Another calls for a small firm to publish and use its marketing expertise to promote a CD-ROM product containing a bibliographic database. Still another calls for a database vendor to include the NTIS Database as part of a new package the vendor is marketing to the academic community. The package consists of the databases plus search and retrieval software for mounting on the college or university's own computer.

- Investing resources in evaluating new technologies, especially optical disk.

- Revamping completely the NTIS "Foreign Technology Newsletter." It now has a new front section with reviews and syntheses of major research programs, activities of specific organizations and laboratories, conference summaries, and descriptions of specific new technologies, processes, and discoveries. Contributing sources include the Office of Naval Research, the Foreign Broadcast Information Service, and U.S. embassies. This is in addition to coverage of foreign research and development reports in such fields as advanced micro-electronics, structural ceramics, and superconductivity.

- Establishing a task force to perform a requirements analysis and a design for a new bibliographic input system.

- Reaching an agreement with OCLC so that subscribers to their service can order NTIS reports online.

- Establishing a number of pilot projects with organizations who have the subject expertise to select the most useful information from the NTIS Database and to make its availability known to interested segments of U.S. business and industry.

NTIS will continue to modernize its procedures, systems, and equipment in order to give the best possible customer service. Providing technical information that is properly organized and rapidly accessible is of the utmost importance in today's competitive environment.

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(formerly National Bureau of Standards)
Gaithersburg, MD 20899
OFFICE OF THE DIRECTOR

JAN 31 1989

Honorable Neal Smith
Chairman
Subcommittee on Commerce, Justice, and
State, the Judiciary, and Related Agencies
Committee on Appropriations
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

The Department of Commerce Appropriations Act for fiscal year 1989 (Public Law 100-459) directs the National Institute of Standards and Technology (NIST) to develop and fund a cooperative agreement for the establishment of a center for integrated design, non-destructive evaluation and manufacturing. The Act also directs NIST to report to the House and Senate Committees on Appropriations on the status of this cooperative agreement by February 1, 1989.

I am pleased to report that on January 25, 1989, NIST, Iowa State University and Northwestern University announced plans to develop a research center to study how advanced technology can help improve the quality of American products. This new center, which will be developed during a three-year partnership between these institutions, will examine how computer design and information technologies, dubbed "CAD/CAI" (Computer Aided Design/Computer Aided Integrity), will integrate elements of non-destructive evaluation (NDE), fracture mechanics, stress analysis, materials science, statistics, and economic analysis.

The center will be funded over a three-year period by the $7.5 million earmarked for that purpose in the NIST FY89 appropriation. Iowa State University and Northwestern University plan to provide an additional $2.1 million for the project.

We have this date signed the grant award and cooperative agreement and forwarded them to Iowa State University by Federal Express Mail. I am enclosing a copy of a Department of Commerce press release on the new Center for your information. If you require anything further, our Congressional Affairs Director Esther Cassidy will be pleased to help you. She can be reached on 975-3080.

Sincerely,

Raymond G. Kammer
Acting Director

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
NEWS
GAITHERSBURG, MD 20899

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

FOR RELEASE:
Jan. 25, 1989

G 89-7

CONTACT: Michael Baum
(301) 975-2762

# NEW RESEARCH CENTER WILL EMPHASIZE IMPROVED PRODUCT-DESIGN TECHNOLOGY

The Commerce Department's National Institute of Standards and Technology (NIST), Iowa State University (ISU) and Northwestern University today announced plans to develop a research center to study how advanced technology could help improve the quality of American products.

The proposed center, to be developed during a three-year partnership between the institutions, will study how computer-based techniques could improve product quality--widely recognized as one of the key battlefields in international trade.

The center will examine how computer design and information technologies could be used to help designers to build quality and structural integrity into a product during the early stages of development.

These technologies, dubbed "CAD/CAI" (Computer-Aided Design/Computer-Aided Integrity), will integrate elements of non-destructive evaluation (NDE), fracture mechanics, stress analysis, materials science, statistics, and economic analysis.

Computers, using modern information technology tools such as expert systems, would give the designer access to the information necessary to build the optimal combination of reliability, ease-of-service, and life-cycle cost into the original product design. Such systems could avoid costly and time-consuming design changes in the manufacturing and testing stages of a new product.

- more -

The ISU center will benefit from several existing programs at the university, including a widely recognized center for NDE research, and the U.S. Department of Energy's Ames Laboratory, an important facility for materials research, as well as the engineering, materials science, and statistics departments of ISU and Northwestern.

The center also will have ties to active NIST programs in NDE, materials science, and manufacturing technology, particularly the NIST Automated Manufacturing Research Facility (AMRF).

NIST received a special appropriation of $7.5 million in its FY 1989 budget to fund the new center over a three-year period. ISU and Northwestern University plan to provide an additional $2.1 million for the project. Details of the agreement between the three institutions are being negotiated.

-30-

AMERICAN SOCIETY OF CIVIL ENGINEERS

Washington Office
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(202) 785-4454

March 28, 1989

The Honorable Doug Walgren
Chairman
Subcommittee on Science, Research, and Technology
2319 Rayburn House Office Building
Washington, D.C. 20515

Dear Chairman Walgren:

The attached statement of the American Society of Civil Engineers (ASCE), on behalf of the American Association of Engineering Societies (AAES), the National Society of Professional Engineers (NSPE), and the Society of Fire Protection Engineers (SFPE), urges Congress to reject the Administration's proposed FY 1990 budget cuts in the Centers for Building Technology (CBT) and Fire Research (CFR) of the National Institute of Standards and Technology. Please include our statement in the committee's hearing record.

Merging CBT and CFR and reducing their combined budgets by 47%, from $9.372 million in FY 1989 to $5 million in FY 1990, would seriously jeopardize the unique and important research activities of these two outstanding centers. Inflation and previous cuts have already curtailed essential program activity at CBT and CFR. Any further cuts at this time should be rejected.

Mr. Chairman, the Science, Research, and Technology Subcommittee has traditionally played a vital role in preserving CBT and CFR. Once again, ASCE, AAES, NSPE, and SFPE respectfully request that the Centers for Building Research and Fire Research be spared unwise and drastic budget cuts.

Your attention to our concerns regarding this matter is deeply appreciated.

Sincerely,

Casey Dinges

Casey Dinges
Legislative Affairs Manager

*Civil engineers make the difference*
*They build the quality of life*

STATEMENT OF

THE

AMERICAN SOCIETY OF CIVIL ENGINEERS

ON BEHALF OF THE
AMERICAN ASSOCIATION OF ENGINEERING SOCIETIES
NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS
SOCIETY OF FIRE PROTECTION ENGINEERS

# FISCAL YEAR 1990 BUDGET
# FOR THE
# CENTER FOR BUILDING TECHNOLOGY
# CENTER FOR FIRE RESEARCH
# NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

SUBMITTED TO THE
SCIENCE, RESEARCH, AND TECHNOLOGY SUBCOMMITTEE

SCIENCE, SPACE, AND TECHNOLOGY COMMITTEE

UNITED STATES HOUSE OF REPRESENTATIVES

Washington, D.C.
March 28, 1989

The American Society of Civil Engineers (ASCE), on behalf of the American Association of Engineering Societies (AAES), the National Society of Professional Engineers (NSPE), and the Society of Fire Protection Engineers (SFPE) representing over a half-million engineers, strongly opposes the Administration's fiscal year 1990 budget request for the Centers for Building Technology and Fire Research in the National Institute of Standards and Technology (NIST).

The Administration's fiscal year 1990 budget proposal calls for merging the Center for Building Technology (CBT) and the Center for Fire Research (CFR) and drastically cutting available funds for these unique and important programs. The Administration proposes to cut NIST building research and fire research to $5 million base funding in fiscal 1990, down 47% from 9.372 million in fiscal 1989.

The Administration's budget proposal continues an effort that began in the fiscal year 1983 budget request to eliminate or drastically reduce these vitally important programs. Each year, Congress has wisely preserved CBT and CFR.

This latest attempt to merge and purge the building and fire research centers would limit building research to building safety, and fire research to reduced efforts in toxicity studies and fire modeling. Enactment of these proposed cuts would eliminate research in the following areas:

- durability of roofing and protective coatings
- indoor air quality and ventilation
- hear and moisture transfer through walls and roofs
- alternatives to those refrigerants depleting the ozone layer and contributing to the greenhouse effect
- test method for the flammability of upholstered furniture

- o determination of the properties of materials which affect performance in fire
- o university grants for fire extinguishment techniques and materials behavior in fires

As in previous fiscal years, when the Administration even proposed outright termination of CBT and CFR, the rationalization for merging and cutting these research programs is that the resulting void will be filled by the private sector or state and local government. This justification, which this committee and the Congress have rightly rejected in recent years, belies the numerous statements filed on behalf of a variety of organizations that stressed the valuable role performed by the Centers for Building Technology and Fire Research. The continued budget assault on CBT and CFR is, indeed, perplexing if not alarming, particularly in light of the Administration's expressed commitment to improving U.S. economic competitiveness and technological development and excellence. Foreign competitors continue to strengthen their position in the construction industry through increasing research and development. NIST building and fire research enhances the usefulness, safety and economy of buildings and strengthens the international competitiveness of U.S. construction services and products.

ASCE, AAES, NSPE, and SFPE want Congress to know that we support, without equivocation, full funding for CBT and CFR. The specialized laboratory facilities and expert professional staffs of the Center for Building Technology and Center for Fire Research are essential public resources that should be preserved, and not destroyed.

CENTER FOR BUILDING TECHNOLOGY

The Center for Building Technology is the national building research laboratory. It performs field, laboratory and analytical research to develop measurement techniques and to evaluate the performance of construction materials, components, and systems. The program has made valuable contributions to U.S. competitiveness through substantial efforts in structural reliability, advanced refrigerants and improved refrigeration cycles, seismic design and construction standards, rehabilitation standards, building energy conservation standards, insulation measurements, roofing standards, corrosion-resistant reinforcing steel, and prediction of the service life of building materials. CBT research provides engineers with the sound technical information they need to make responsible and cost-effective decisions in the building process.

CBT is the only research program that integrates complex technical issues affecting the vast building industry. Despite the fact that it amounts to about 9% of the GNP, and that almost two-thirds of the nation's wealth is invested in constructed facilities, the building industry is desegregated. Private sector R & D is limited essentially to product development by materials and components manufacturers. Because of the industry's size and diversity, it is difficult to imagine any institution in the private sector or at the state level duplicating CBT's efforts or adequately distributing the findings on its own. This interdisciplinary laboratory also integrates complex technical issues in a way that more narrowly-focused proprietary research and development cannot.

CBT's top accomplishments in 1988 are noteworthy indeed. The Center for building Technology:

- Published an award-winning paper "Quest for Alternatives: A Molecular Approach Demonstrates Tradeoffs and Alternatives are Inevitable in Seeking Refrigerants," which describes the systematic, CBT-developed approach to identifying alternatives to environmentally-harmful refrigerants.

- Conducted an investigation into the collapse of the oil tank operated by Ashland Petroleum Co. on January 2, 1988, near Pittsburgh, PA.

- Reported on a series of inelastic cyclic load studies of full- and 1/6-scale model tests of highway bridge columns designed in accordance with recent California Department of Transportation guidelines.

- Completed experimental study on punching shear behavior of heavily reinforced, lightweight concrete slabs and shells designed to have dimensions, material properties, and boundary conditions that are typical of the perimeter wall of an Arctic offshore structure. The results of this research have been incorporated by some oil companies, who sponsored this project, in their design of offshore concrete structures.

- Developed interim performance criteria for modified bitumen roofing membranes. The criteria are expected to provide a benchmark for these relatively new systems and become the technical basis for an ASTM standard.

- Developed for the Department of Defense, a revised Paints and Coatings Manual which incorporates recent technological developments. The Manual is widely used as a reference both in the public and private sectors.

- Installed a prototype air quality diagnostic center in the new Federal Office Building in Portland, Oregon. Tests were performed on ventilation rates, carbon monoxide, carbon dioxide, respirable suspended particulates, formaldehyde, radon and volatile organic compounds.

CBT's planned accomplishments for FY 1990 include the following:

- Report on laboratory studies of precast concrete beam-column connections with and without tensioning will be completed. Seismic behavior of precast concrete structures is dependent largely on the strength and ductility of connections of precast elements.

- Develop analytical techniques accounting for additions or removals of structural members. These techniques are needed for studies of the stability of structures under construction and analyses of sequences of events in structural failures.

- Recommendations for the design of reinforced concrete masonry structures for seismic loadings. Based on extensive laboratory studies, cost-effective procedures will be recommended for seismic safety in the eastern United States.

- Provide thermodynamic and transport property data for refrigerants 32, 124, 125, 134, and 143a, the remaining leading replacements for refrigerant 11 and 12 that are depleting the ozone levels in the stratosphere and consequently are being phased out of use.

- Guidelines for the design and construction of commercial buildings to prevent unwanted energy losses due to thermal bridges, air leakage, and moisture transfer.

- Verification of test methods for evaluating commercial building ventilation system performance and indoor air quality.

This impressive array of research activities clearly underscores the national importance attached to the Center for Building Technology.

The following case illustrates the vital role CBT provides to the building industry. On January 1, 1985, the management responsibility for the ANSI (American National Standards Institute) A58-1984 Standard, "Minimum Design Loads for Buildings and Other Structures," was transferred from CBT to ASCE. this standard is the only nationally recognized voluntary consensus on structural loads in the United States. It is widely used as a resource document by other codes and standards groups, regulatory authorities and engineers confronted with unusual design situations not covered by building codes.

Though management of the Standard will now reside with ASCE, and thereby with the private sector, CCBT will continue to be the principal source of new technology to update ANSI A58. CBT programs such as Wind Loads on Buildings, Seismic Design Criteria, Floor Loads, Fire Loads, Reliability Analysis and Design Analysis have been and will continue to provide invaluable input for the standard. Without future technological support by CBT programs, the future of this important standard will be seriously compromised.

## CENTER FOR FIRE RESEARCH

The Center for Fire Research also contributes to public safety in a way that no privately-funded research effort could. CFR explores the processes that initiate, propagate and suppress real fires. As a result, realistic material test methods of fire control and extinguishment can be developed. Like CBT, CFR does not promulgate or enforce standards or regulations. Instead, it provides technical support to voluntary standards and model codes groups, engineers, the building industry and fire organizations.

CFR is the world leader in the development of mathematical fire models and computer simulation. Given the disturbingly high fire death rate in the U.S., the importance of CFR programs cannot be overemphasized. Despite an improved U.S. fire loss record over the last decade, each year U.S. fires result in over 6,000 deaths, 200,000 injuries, and $7.5 billion in property losses. CFR is the only comprehensive research program in the U.S. directed at reducing fire deaths, injuries, and costs due to fire. Significant reduction of the Center for Fire Research would cripple progress towards this

goal of reducing loss of life and costs by halting essential basic and slowing applied research, leaving U.S. industry without critical inputs from CFR.

CFR activities establish the basis for improved fire safety while providing engineers, architects, building owners and occupants, and code officials with the ability to provide the necessary fire safety at reduced cost and greater flexibility. Increased use of scientifically-based models and evaluation tools could lead, by the end of the century, to further reductions in fire deaths of as many as 3,000 lives per year and fire protection costs to society of $15 billion per year. Examples of CFR research that have contributed to reducing the U.S. death rate by over 20% in the last decade are search on smoke detectors, cigarette resistant mattresses and furniture, fire safe children's sleepwear, quick acting residential sprinklers, and fire safety evaluation systems for health care and many other special occupancies. In addition to the in-house research, the Center for Fire Research supports fundamental fire research at about 25 universities and other organizations.

The CFR Office of Technology Transfer disseminates important scientific and technical information to the user community. The Fire Science and Engineering Division develops methods to measure the fire properties of materials and the means to predict fire behavior and smoke dynamics in structures, in addition to providing useful engineering methods to fire safety engineers and code organizations. Research in this division includes combustion and flammability, fire dynamics, building fire modeling, and fire safety engineering.

The Fire Measurement and Research Division covers smoke dynamics research, fire toxicity measurement, fire hazard analysis, and fire suppression research. CFR also conducts research programs for numerous agencies of government and for private organizations on a reimbursable basis.

Ongoing CFR research programs range from fundamental studies of flame chemistry and polymer degradation to the development of engineering tools and systems. Much of this research is directed towards the development of the ability to predict fire growth and spread, smoke spread, fire hazard, and fire risk. Current programs include measurement methods for fire properties, the simulation laboratory, engineering for fire protection applications, fire hazard assessment, transport physics, wall fires, extinguishment, turbulent burning and expert systems for Model codes.

Recent accomplishments at the Center for Fire Research underscore CFR's importance to the nation.

- CFR has developed analytical and predictive methods to assist in the investigation and reconstruction of major fires, such as the Dupont Plaza Hotel fire in Puerto Rico and the First Interstate Bank building fire in Los Angeles.
- CFR developed the technology for extinguishing or controlling gas and oil well blowout fires with relatively small water sprays.
- CFR assisted in nuclear winter calculations by providing detailed measurements of fire energy release rates, and near to the fire plume temperatures, velocities and soot concentrations.
- CFR experiments have led to major revisions to the installation criteria and codes for solid fuel burning appliances resulting in major reductions in fire losses.
- CFR has demonstrated and is using a technique to simulate smoke flow through complex structures using dyed salt water in a scale model filled with fresh water.

- o CFR's Fire Simulation Laboratory transfers analytical fire safety tools to the practicing fire protection community.

If the specter of eliminating lifesaving opportunities does not deter efforts to curtail the CFR, the cost-saving implications should persuade a budget-conscious government to reconsider the proposal. Fire-safe building design techniques can save money for all sectors of our society.

## CONCLUSION

ASCE, AAES, NSPE, and SFPE commend efforts to reduce the federal budget deficit, but we must also warn against the myopic reduction of essential and technically excellent programs that will not be duplicated fully by the private sector. At the very least, we urge Congress to sustain FY 90 funding for CBT and CFR at the FY89 level of 9.372 million. It is important to note, however, that inflation and prior cuts have diminished CBT and CFR research resources by one-half in the past decade. During this period, CBT has been given new responsibilities such as earthquake hazards reduction and structural failure investigations without new resources. Federal agencies with building-related programs now sponsor less, not more, research as their building programs have been curtailed.

Congress should begin to examine the issue of full restoration of funding for the essential building and fire research programs of NIST.

## AMERICAN SOCIETY OF CIVIL ENGINEERS

The American Society of Civil Engineers (ASCE), founded in 1852, is the oldest national engineering society in the United States.

Membership, held by more than 100,000 individual professional engineers, is about equally divided among engineers in private practice; engineers working for federal, state or local governments; and those employed in research and academia. The Society's major goals are to develop engineers who will improve technology and apply it to further the objectives of society as a whole, to promote the dedication and technical capability of its members and to advance the professional and economic stature of civil engineers.

AMERICAN ASSOCIATION OF ENGINEERING SOCIETIES

The American Association of Engineering Societies (AAES) is a multi-disciplinary organization dedicated to advancing the knowledge, understanding, and the practice of engineering in the public interest. Located in Washington, D.C., AAES includes 13 member societies, 6 associate societies, and 3 regional societies representing over 500,000 engineers in industry, government and education.

NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS

The National Society of Professional Engineers (NSPE), is a professional society, representing more than 75,000 engineers of all disciplines nationwide. The members are organized into 54 state and territorial societies and 535 local chapters, and work in industry, education, private practice, construction, and government.

SOCIETY OF FIRE PROTECTION ENGINEERS

The Society of Fire Protection Engineers (SFPE) is the international technical society for engineers involved in the multifaceted field of fire protection engineering. SFPE has 3,100

members located primarily in the United States, including engineers in private practice, in industry, in government, in manufacturing and installation of fire protection equipment, as well as technical members of the fire and casualty insurance industry. Fire protection engineers largely determine fire safety for all Americans through their impact on the designs of buildings and plants, both public and private, and their contribution to setting codes and standards. To achieve cost effective, relevant and engineered fire safety requires a solid scientific, technological base.

TELEPHONE: 313-532-2600
TELEX: 810 2211454
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american concrete institute

BOX 19150
22400 WEST SEVEN MILE ROAD
DETROIT, MICHIGAN 48219

March 10, 1989

RECEIVED
MAR 16 1989
Co... on Science, Space, and Technology

The Honorable Robert A. Roe
Chairman, Subcommittee on Science,
Research and Technology
House of Representatives
Suite 2321
Washington, D. C. 20515

Re: Fiscal Year 1990 Appropriations for the National Institute of Standards and Technology

Dear Congressman Roe:

We understand that the Administration's budget proposal for fiscal year 1990 calls for reductions in total appropriations for building and fire research at the National Institute of Standards and Technology (NIST) to $5 million annually, which is half of the $9.4 million level for fiscal year 1989. The American Concrete Institute, through its Executive Committee, contacted members of the Subcommittee last year regarding the activities of NIST (then NBS) and its Center for Building Technology (CBT). The Committee has agreed to resubmit its comments on the value of building research conducted by NIST.

In general, we stand behind efforts being made by Congress and the Administration to bring the nation's debt load under control by reducing the cost of government. However, reduction of building and fire research activities at NIST, as proposed this year and in past years, might result in a greater cost to the nation than the savings realized. In the Committee's opinion, NIST and CBT can provide research capabilities and perspectives in the area of national safety which are difficult to duplicate in the private sector. It would be desirable for NIST to continue those aspects of research and development.

There is a need to have a research center in this country that deals with safety related to building performance. NIST has that capability. Elimination of these programs would diminish the effectiveness of NIST as a national building research laboratory.

american concrete institute



We recommend that NIST and CBT be provided with sufficient funding to permit them to properly accomplish their principal objectives. These include conducting research and providing support for private sector standards developers such as ACI, and the carrying out of research programs which may increase the safety of building construction. We do not support funding, either direct or indirect, that would result in NIST competing with universities or privately owned engineering firms and laboratories, as this would result in the use of tax money by a government agency to take work away from either the private sector or other public organizations. The research and development activities of NIST, as well as the contributions of its staff, have helped the standards developing efforts of ACI. We would like to see NIST maintain this capability.

For background, the American Concrete Institute is a nonprofit technical society whose purpose is to further engineering and technical education and scientific research on concrete. ACI is a voluntary consensus standards-developing organization and publishes standards on concrete design and construction using procedures approved by the American National Standards Institute (ANSI). We are an individual membership society of almost 20,000 members and membership is open to anyone interested in the design, construction or use of concrete.

We hope these comments are of help to you in reaching a decision on the authorizations and appropriations level for NIST for the forthcoming Fiscal Year.

Very truly yours,

George F. Leyh
Executive Vice President
(For the Executive Committee of the American Concrete Institute)

GFL:dsk

cc: ACI Board of Direction

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC.
The Wrigley Building ■ Eighth Floor ■ 400 North Michigan Avenue ■ Chicago, Illinois 60611-4185 ■ Telephone (312) 670-2400

NEIL W. ZUNDEL
President

Direct Dial Number:
(312) 670-5401

March 10, 1989

Honorable Robert A. Roe
Chairman, Committee on Science, Space and Technology
Suite 2321 House of Representatives
Washington, DC 20515

Dear Mr. Roe :

It is our understanding that the Administration's budget for fiscal year 1990 again proposes major reductions for the Center for Building Technology (CBT) and the Center for Fire Research (CFR) at the National Institute of Standards and Technology (NIST). The American Institute of Steel Construction, Inc. (AISC) is a trade organization representing fabricators, erectors, structural engineers and educators, who are involved in fabricated steel construction that totals approximately five million tons of mill steel per year. We highly value the Centers' important contributions to advancing building technology, such as standardization of loads, earthquake disaster mitigation, and special failure investigations. Therefore, AISC strongly urges that at least the current federal support levels be maintained for CBT and CFR.

The U.S. construction industry is widely recognized as being fragmented, diverse and very competitive without a dominant leader or innovator. With the progressive deterioration of the nation's infrastructure, intermittent concerns about building and occupant safety, and strong market pressures from abroad, the presence of distinguished and authoritative central laboratories at NIST to deal with such crucial issues is of paramount importance. CBT and CFR have the unique opportunity to serve as leaders and catalysts for expanding cooperative studies with industry and academia on key topics. Only they can identify and address problems that transcend the narrower scope of the various construction interests, thereby helping to supplement the relatively modest research and development efforts of this private sector.

AISC realizes the urgent need to control federal funding in order to reduce the budget deficits. However, upon a careful reconsideration of the past CBT and CFR contributions and the future needs of the U.S. construction industry, we trust that you will agree that both CBT and CFR merit acknowledgment and continued priority support as a national resource. The proposed NIST funding reductions would be a severe setback to both the public interest, in general, and to construction, in particular and should be rejected. AISC, on behalf of its Membership, recommends full federal support of these major technical Centers.

Respectfully submitted,

Neil W. Zundel
Neil W. Zundel

cc: G. Haaijer
N. Iwankiw

THE RYLAND GROUP, INC.

Charles E. Peck
Chairman of the Board

March 28, 1989

The Honorable Doug Walgren, Chairman
Subcommittee on Science, Research
and Technology
Suite 2321
House of Representatives
Washington, DC 20515

Dear Congressman Walgren:

I understand that the administration proposes to reduce the National Institute of Standards and Technology building research and fire research to a $5 million base in fiscal 1990 from $9.372 million in fiscal 1989. This severe cut off of funds would result, I believe, not just in the loss of work on important projects but, even more importantly, in the final break-up of the building research talent pool which has been serving the nation's needs.

How illogical it is to destroy this national asset at a time when it is clear that other governments are succeeding in taking work away from Americans by bringing technical support to their key industries!

The Ryland Group is a construction firm, listed on the New York Stock Exchange, with annual revenues of $1,272,000,000. While we do not currently build in the Pittsburgh area, we are active in sixteen states across the country. There are many, many ways in which the work of the building and fire research groups at the NIST have made our work more efficient and effective, thereby lowering the costs, or improving the safety, or bettering the performance of our buildings to the end consumer.

I hope that you, in your role as chairman of the Subcommittee on Science, Research and Technology, can help restore funds to this vital organization.

Sincerely,

C. E. Peck

CEP:jkc

0002B

THE RYLAND GROUP BUILDING
10221 WINCOPIN CIRCLE/BOX 4000/COLUMBIA MARYLAND 21044/PHONE (301) 730-7222

EARTHQUAKE ENGINEERING RESEARCH INSTITUTE

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Susan K. Tubbesing, Executive Director

6431 FAIRMOUNT AVENUE, SUITE 7, EL CERRITO, CALIFORNIA 94530-3624

March 9, 1989

Honorable Robert A. Roe
Chairman, Committee on Science, Space
and Technology
Suite 2321, House of Representatives
Washington, D.C. 20515

Dear Congressman Roe:

On behalf of the Earthquake Engineering Research Institute I am writing to express our support for the Center for Building Technology at the National Institute of Standards and Technology. We are concerned that the proposed administration budget cut of more than $4 million, will seriously compromise the ability of the Center for Building Technology to carry out its mandated activities. CBT has a critical role to play in earthquake hazard reduction and structural failure investigations. While the proposed cuts in the building research programs are not tied directly to CBT's earthquake activities, the extent of the reduction will undoubtedly jeopardize the overall effectiveness of NIST and its work in this critical area as well.

We believe CBT has made significant contributions over the past several years to the development of performance criteria for buildings and other structures, and the Center's work in the fire area has a direct bearing on our ability to reduce losses posed by the post earthquake fire hazard. We urge that Congress act quickly to restore the 4.3 million to the FY 1990 budget, to bring it back to its 1989 funding level.

The Earthquake Engineering Research Institute (EERI) is a nonprofit, national, technical society of engineers, geoscientists, architects, planners, and social scientists who are engaged in diverse aspects of earthquake hazard reduction. We believe that the Center for Building Technology carries out valuable work of interest to our members, to the construction industry as a whole, and specifically in the area of earthquake engineering research.

98-198 0 - 89 - 25

We believe this work should continue and strongly endorse maintaining the current level of funding for the Center for Building Technology at the National Institute of Standards and Technology.

Sincerely,

Susan K. Tubbesing
Executive Director

SKT:lb

cc: Board of Directors

# AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS

JAMES P. PITZ, President
Director
Michigan Department of
Transportation

FRANCIS B. FRANCOIS
Executive Director

March 20, 1989

The Honorable Doug Walgren, Chairman
House Subcommittee on Science, Research
and Technology
2241 Rayburn House Office Building
Washington, D.C. 20515

Dear Congressman Walgren:

The Congress will shortly be considering the authorization for the National Institute of Science and Technology. The Administration's FY 1990 budget request calls for, among other things, a considerable reduction in building and fire research. I have been led to believe that such a reduction could adversely impact, perhaps even eliminate, the highly successful Research Associate program at the NIST in which AASHTO has long been active.

The American Association of State Highway and Transportation Officials (AASHTO) is the national association of State departments of highways and transportation. AASHTO has no private sector membership, and functions as an extension of State government. Among their duties in dealing with all transportation modes, the State agencies comprising AASHTO are responsible for planning, designing, constructing and operating the nation's principal system of highways. An important part of that responsibility is an adequate program of quality assurance with respect to the materials used in the construction and maintenance of our highways. This quality assurance role is accomplished through a materials division in each of the departments, each of which operates one or more materials laboratories to conduct the necessary testing and evaluation.

Recognizing the importance of consistency in such materials testing across the country, the AASHTO Materials Reference Laboratory (AMRL) was established in 1965 under a Research Associate agreement with the then National Bureau of Standards, now NIST. The purpose of the AMRL was and is to provide a quality assurance program for the State materials laboratories themselves. This has been accomplished through two programs, both of which now are done by the AMRL under the overall auspices of the National Institute of Science and Technology and its Center for Building Technology. These are:

EXECUTIVE OFFICE: 444 N. Capitol St., NW. Suite 225, Washington D.C. 20001
Telephone (202) 624-5800 Telefax (202) 624-5806 Telex 4900009580 HTO

- A proficiency sample program which distributes over 2,000 samples annually and where test results from participating laboratories on soil and asphalt samples prepared from a central source are statistically evaluated for consistency, and

- On-site assessments of over 150 state and independent laboratories conducted on a rotation cycle of approximately 24-months duration.

Though managed by NIST, the cost of this program is borne exclusively by AASHTO. In turn, AASHTO receives funds to support the program from each one of the fifty-two State highway and transportation agencies, from the Federal Highway Administration, and from a number of other governmental and private laboratories who voluntarily choose to avail themselves of AMRL's quality assurance reviews. Thus the program, like all other Research Associate programs to my knowledge, is funded entirely by its sponsor, ourselves, with no demand on Congressionally appropriated public funds.

With the perspective of 24 years hindsight, the AMRL program has indeed been a success. The State highway and transportation departments have been afforded a sound, well managed mechanism to assure the quality and consistency of their materials laboratories and other laboratories which test materials used in transportation systems. We feel the involvement of NIST in our program has been pivotal to its success for several reasons. Among these are the prestige and near unassailability attendant to the involvement of, and objective management by, the nation's principal scientific measurement agency. Another is the distinct absence of a federal regulatory role; the service provided through the NIST merely provides a basis on which the States may regulate themselves. We fear these important factors could be lost if the current budget proposal is approved.

AMRL is taking on an even more important role through the AASHTO Accreditation Program (AAP) which the AASHTO Executive and Policy Committees approved for implementation in June, 1988. The AAP will provide a mechanism for formally recognizing the competency of a laboratory to carry out specific testing of materials used in the nation's transportation systems. The AMRL on-site assessment and proficiency sample programs discussed above will be the primary technical components used to evaluate laboratory performance. Accreditation decisions will be made by the AASHTO Highway Subcommittee on Materials based on the results of laboratory participation in the AMRL programs.

There is another similar program also now placed in jeopardy by the budget proposal. This is the Cement and Concrete Reference Laboratory (CCRL), sponsored through NIST in virtually an identical fashion as the AMRL, but by the American Society for Testing Materials (ASTM). Our State highway and transportation departments also avail themselves of this service coincidentally with that afforded by AMRL, and compensate the CCRL program through fee payments. These two programs are closely related in that they each serve

many of the same clients and are now managed by the same NIST employee. CCRL programs for concrete and aggregates will be utilized in the AASHTO Accreditation Program for accreditating such laboratories. Thus, many of the comments on AMRL, above, are equally applicable to CCRL.

I would be pleased to provide any additional information you may wish. You can call me, or my Deputy Director, Mr. David Hensing at 624-5800.

Very truly yours,

Francis B. Francois
Executive Director

FBF:DJH:jan

Enclosure

cc: The Honorable Sherwood L. Boehlert
Subcommittee on Science, Research and Technology
The Honorable Constance A. Morella
Subcommittee on Science, Research and Technology
The Honorable Robert A. Roe, Chairman
Committee on Science, Space and Technology
The Honorable Robert S. Walker
Committee on Science, Space and Technology
The Honorable Neal Smith, Chairman
Subcommittee on Commerce, Justice, State, The Judiciary
and Related Agencies

900 Spring Street
Silver Spring, Maryland 20910
United States of America
(301) 587-1400

NRMCA

National
Ready Mixed
Concrete
Association

March 31, 1989

The Honorable Doug Walgren, Chairman
Subcommittee on Science, Research and Technology
2321 Rayburn House Office Building
Washington, DC 20515

Dear Representative Walgren:

The National Ready Mixed Concrete Association (NRMCA) would like to urge the restoration of the meager funding for the Center for Building Technology (CBT) of the National Institute of Standards and Technology for fiscal year 1990.

The NRMCA represents approximately 1000 producers of ready mixed concrete in the United States who produce approximately 60 percent of the total concrete production. Our technical and research staff are involved with CBT personnel in numerous professional and technical societies. We are well aware of the contributions CBT has made, and continues to make, to the public interest on vital construction related issues.

Specifically, we are concerned that CBT's effectiveness will be greatly reduced if the proposed cuts in appropriations are not restored.

CBT's contributions to the following building code, and technical and consensus standards-writing societies are greatly valued and must not be reduced. The value to the public greatly exceeds the modest annual cost. We are most familiar with CBT's contributions to the following technical and standards-writing bodies:

American Society for Testing Materials (ASTM)
American National Standards Institute (ANSI)
American Society of Civil Engineers (ASCE)
National Conference of States on Building Codes
American Concrete Institute (ACI)
Transportation Research Board (TRB)
Building Seismic Safety Council (BSSC)
American Society of Heating, Refrigerating and Air Conditioning Engineers

Examples of the work CBT has done in the past and projects proposed for the future are impressive. For example, CBT's investigation of the Kansas City hotel walkway collapse was instrumental in urging ASCE to develop a manual on "Building Quality in the Constructed Project" which promises to change and improve the way the construction industry operates in the U.S. Public safety is receiving attention that is greatly needed. The CBT had a central role in development and revision of ANSI Standard A 58 "Minimum Design Loads for Buildings and Other Structures." Their work on non-destructive testing and quality assurance in concrete construction has had an important impact on standards and codes. In numerous instances CBT has provided the research and insight necessary for changing obsolete practices and procedures.

The proposed study of precast beam-column connections is urgently needed as is the proposed study of analytical techniques for determining stability of structures.

The CBT is a catalyst for progress that cannot be replaced by the private sector. It has an excellent track record and is a recognized leader in the construction research community. Its expertise is sorely needed. We, therefore, respectfully request full funding for fiscal year 1990.

Respectfully yours,

Richard D Gaynor

Richard D. Gaynor
Executive Vice President

RDG:sfh

# HEALTH PHYSICS SOCIETY

R. E. ALEXANDER, President
13131 Maltese Lane
Fairfax, VA 22033
Telephone: (703) 378-6720

March 3, 1989

Mr. James Turner
Counsel
Subcommittee on Science, Research, and Technology
Committee on Science, Space, and Technology
2319 Rayburn House Office Building
Washington, DC 20515

Dear Mr. Turner:

Due to the increasingly competitive nature of international commerce, it is necessary for the United States Government to maintain a position of leadership in the field of reference standards that are used by industry, government agencies and universities. The importance of reference standards was recognized long ago by the Department of Commerce and the National Bureau of Standards (which is now the National Institute of Standards and Technology, NIST). U.S. industries rely on measurements that are traceable to the NIST in order to assure that their products are of a consistently high quality and are interchangeable, within required tolerances.

In the field of ionizing radiation measurements, the maintenance of national reference standards is particularly important, because such measurements may affect the health and safety of large numbers of workers, as well as the public. Lately, however, there has been an increasing concern on the part of many radiation measurement experts that the ability of the NIST to maintain high quality reference standards for ionizing radiation measurements is being compromised, or eliminated.

Ionizing radiation measurements are carried out in many medical institutions. The quantity of radiation that is administered for human cancer radiation therapy must be uniform throughout all such institutions, and must be accurate. The only practical way to demonstrate that such measurements are accurate is to provide evidence that they are consistent with, or traceable to, national standards.

In the field of radiation protection, measurements of ionizing radiation are made to ensure that certain work areas are safe to enter. Personnel dosimeters are worn by radiation workers, and readings of these devices constitute a legal record of the radiation dose that they have received. In order to satisfy U.S. Government and State regulations, it is necessary that these measurements also be consistent with, or traceable to, national standards.

The importance of national reference standards for ionizing radiation to the industrial manufacturers of measuring devices and to the government agencies that have responsibilities for radiation protection is quite clear. However, there have recently been several disturbing indications that the NIST has not been given sufficient support to properly maintain the national reference standards for radiation measurement. Among these negative indications are the fact that there appear to be no back-ups for key personnel. Many key people have been encouraged, or forced, to retire and no replacements have been hired. Certain services are not available at NIST due to budget cuts, so customers must turn to foreign standards laboratories in England and Germany. Additionally, the equipment available at NIST is not being kept at the level of the state of the art. Many items are outmoded and should be replaced. It is obvious that several European standards laboratories receive proportionally more support than the NIST.

The conclusion of this analysis is that the NIST is not being given the level of support that is consistent with the importance of their mission to maintain ionizing radiation standards for the U.S. At at time when these standards are becoming more crucial to both industry and to the health and safety of the public (witness, the public concern post-Chernobyl and the recent publicity concerning the condition of DOE nuclear weapons production facilities) it appears that support for the NIST is declining. It is, therefore, recommended that the Department of Commerce and the NIST place additional emphasis on regaining the leadership role they had in the past in the area of ionizing radiation standards. This emphasis should be reinforced by appropriate funding for the development and maintenance of ionizing radiation standards by the Department of Commerce and NIST.

Sincerely,

R. E. Alexander
President, Health Physics Society

REA/kdb
doc4120b/4121b

101st CONGRESS 1st SESSION

HOUSE OF REPRESENTATIVES

Under clause 2 of Rule XXIV, executive communications were taken from the Speaker's table as follows:

COMMUNICATION 0527 from the

Secretary of Commerce

transmitting

the department's first report from the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation for the period ending December 31, 1988, pursuant to Pub. L. 100-418, Sec. 5122(d).

Referred to the Committee on Science, Space and Technology. February 2, 1989.

S+T

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

JAN 19 1989

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TO566

JAN 30 1989

Honorable James C. Wright, Jr.
Speaker of the House of
Representatives
Washington, DC 20515

Dear Mr. Speaker:

I am pleased to submit the first report from the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation, U.S. Department of Commerce, for the period ending December 31, 1988, in compliance with Section 5122(d) of the Omnibus Trade and Competitiveness Act of 1988.

Sincerely,

Secretary of Commerce

Enclosure

# FIRST REPORT TO CONGRESS

## CLEARINGHOUSE FOR STATE AND LOCAL INITIATIVES ON PRODUCTIVITY, TECHNOLOGY, AND INNOVATION

December 30, 1988

Sub-Section 5122(a) of the Omnibus Trade and Competitiveness Act of 1988, Public Law 100-418, signed August 24, 1988, established the Clearinghouse for State and Local Initiatives on Productivity, Technology, and Innovation in the U.S. Department of Commerce. Sub-Section 5122(d) of the Act requires the Secretary to report to the Congress before January 1, 1989 and every three years thereafter on initiatives by State and local governments and on recommendations regarding the appropriate Federal role in stimulating State and local efforts in this area.

Funds for FY 1988 and FY 1989 for the Clearinghouse were provided by Congress, and were included in the Department's general administrative budget.

In order to begin as quickly as possible, the Department of Commerce completed in FY 1988 an interagency agreement with the Advisory Commission on Intergovernmental Relations (ACIR). Under the agreement, ACIR will sample existing compilations of State and local initiatives such as the National Institute of Standards and Technology's compilation of State Technology Extension Services, sample other available information, develop an index for accessing information, and develop an inventory system with an initial data base for use by the Clearinghouse.

The law mandates establishment of the Clearinghouse, but allows wide discretion in its activities. The Department believes that the first step is to determine what information is readily available from the many existing sources and in what ways the Clearinghouse can operate most effectively and efficiently. Accordingly, the Department is planning extensive consultation and coordination with State and local governments and the public interest groups that represent them, other Federal agencies, the Congress, and the private sector, including businesses that provide related information. Where the interests of other Federal agencies or components of the Department of Commerce are closely related to Clearinghouse activities, Memoranda of Understanding may be developed.

The Department is exploring several operating options for the Clearinghouse including privatization; one possibility is to enter into a cooperative agreement with an appropriate

organization, under 15 U.S.C. 1525, to jointly operate the Clearinghouse with a view toward eventually turning the whole operation over to that organization.

Concurrently with organizing the Clearinghouse, the Department of Commerce, pursuant to Title II of H.R. 4417 (Public Law 100-519), is organizing a new Technology Administration under an Under Secretary. The Clearinghouse functions are to be included in this new organization. Therefore, and in keeping with the spirit of the legislation, the Department will submit an interim report by January 31, 1990.

PB89-128276

Current Status of Japanese to English Machine Translation. Report to Congress

(U.S.) Department of Commerce, Washington, DC

Jul 88

PB89-128276

# CURRENT STATUS OF JAPANESE TO ENGLISH MACHINE TRANSLATION

## Report to Congress

by
Tamami Kusuda

July 1988

Office of Japanese Technical Literature
U.S. DEPARTMENT OF COMMERCE
Washington, D.C. 20230

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

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Title: Current Status of Japanese to English Machine Translation. Report to Congress

Date: Jul 88

Authors: T. Kusuda.

Performing Organization: Department of Commerce, Washington, DC. Office of Japanese Technical Literature.

NTIS Field/Group Codes: 92D*, 62F, 70E

Price: PC E03/MF A01

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Number of Pages: 18p*

Keywords: *Machine translation, *Japanese language, *English language, Input, Optical character recognition device, Technology transfer.

Abstract: The primary obstacle to access to the Japanese technical literature is the Japanese language. Manual translation of Japanese technical material tends to be very expensive and, especially in specialized technical fields, is often inaccurate. Machine-aided translation (MT) offers the hope of eventually gaining a much broader access to Japanese scientific and technical literature. The report to the U.S. Congress assesses the present state of Japanese-to-English MT. Consideration is given to the MT process itself, and to current activities in the U.S., Japan and Europe. Attention is also given to the status of optical Japanese character recognition devices as an input method for MT systems.

# Report to Congress

## Current Status
## of
## Japanese to English Machine Translation

**July 1988**


| | |
|---|---|
| C. William Verity | Secretary of Commerce |
| Robert Ortner | Under Secretary of Commerce for Economic Affairs |
| Barry C. Beringer | Associate Under Secretary of Commerce for Economic Affairs |
| Sabina G. Javits | Office of Japanese Technical Literature |
| Tamami Kusuda | Office of Japanese Technical Literature |

# Current Status of Japanese to English Machine Translation
Report to Congress

By Tamami Kusuda, PhD

## ABSTRACT

The primary obstacle to access to the Japanese technical literature is the Japanese language. Manual translation of Japanese technical material tends to be very expensive and, especially in specialized technical field, is often inaccurate. Machine-aided translation (MT) offers the hope of eventually gaining a much broader access to Japanese scientific and technical literature. This report to the U.S. Congress assesses the present state of Japanese-to-English MT. Consideration is given to the MT process itself, and to current activities in the U.S., Japan and Europe. Attention is also given to the status of optical Japanese character recognition devices as an input method for MT systems.

# Japanese to English Machine Translation

T. Kusuda, Office of Japanese Technical Literature

## Introduction

Everyone would agree that the biggest obstacle to the effective use of Japanese technical literature and/or information by American engineers and scientists is the language barrier. The Japanese language is little known outside its native land, and is considered one of the most difficult of the world's major languages for a Westerner in which to gain reasonable fluency . In order to become literate in Japanese technical publications, one must devote a considerable amount of time and concentration to study the language, both of which most engineers and scientists in the United States can ill-afford. It is expected that most Americans will continue to read their Japanese literature in English translation for years to come. There is, however, a shortage of qualified Japanese-to-English technical translators everywhere, inclusive of Japan, and the costs of translation tend to be considerably higher than the costs of translating comparable materials from European languages. (It easily run as high as $100 per page of double spaced technical documents). In addition, the accuracy and "correctness "of translations tends to be low, because translators are usually not proficient in a variety of advanced technical disciplines.

Under these conditions, machine translation appears to offer some hope for alleviating this problem. The development of a fast and accurate machine translation system (or computer aided translation system) would increase the availability of Japanese technical literature in the United States, and expedite the dissemination of Japanese information on scientific discoveries and technical innovations.

## Machine Translation Process

The internal workings of any MT algorithms are extremely complex , and vary according to each individual program. However, in addition to a common words dictionary and a special technical

INTENTIONAL BLANK

dictionary, most Japanese to English MT programs have the following elements: (1) Input editor, or preprocessor (2) Morphological analysis of a string of Japanese characters to form meaningful words, (3) Syntactic analysis of these words to form a syntactic dependency structure , (4) Semantic analysis of the syntactic dependency structure to form a semantic dependency structure for Japanese, (5) Transformation of the Japanese semantic dependency structure into that of English, (6) Syntactic generation of a English phrase structure (tree structure), (7) Morphological synthesis of an English sentence with appropriate tense, articles, preposition and post positions, and number, etc., (This is not easy, because Japanese lacks the concept of articles and in many instances it is sloppy in plurality distinction), and finally (8) Post editing or postprocessor of a translated English sentence. In addition to this basic structure, good MT programs should include algorithms to handle contextual analysis or intersentential relationship using some forms of artificial intelligence technique.

A typical MT process described herein is the so called the "transfer method", which is most popular among current MT systems. There is another machine translation system that uses the "interlingua method", which will be used primarily for multi-lingual translation and described later.

Although considerable advances in MT applied to European languages have been made in recent years, even the current best MT for these European language translation is still far from the [illegible]ge that it can replace human translators. According to W. John Hu[illegible]ns, author of " Machine Translation. Past, Present, Future " (Chichester: Horwood, 1986.), no current operational or established MT system can produce good quality output without either placing restrictions on input or involving human assistance before, during and after translation processes. Since the present MT system makes simple errors which no human translator would possibly make, it is not surprising that in general translators have low opinions of MT systems, including the most advanced systems.

**US Activities in Japanese to English MT**

In spite of strong and expressed needs, US government efforts to develop Japanese-English machine translation are limited to a project under way by the Air Force Foreign Technology Division (FTD) and the Intelligence Community. This project was formally initiated in 1985 following several years of planning and consideration of various machine translation options available in the United States and Japan.

The Intelligence Community chose to support research and development of a Japanese-English Systran System (JESS), based in part on the successful development of a Russian-English Systran system. This Russian system played a vital role during the Soyuz-Apollo mission when large volumes of Russian technical documents had to be rapidly translated into English. In addition, Systran has been implemented for the translation of French, German, Italian, Spanish, Portuguese, and Dutch. At present it is the most widely-used MT system in the world by governments and industry including the US Air Force, NASA, the European Communities (CEC), Xerox Corporation, and General Motors of Canada. Unlike other contemporary MT systems, which rely heavily on high level programming languages such as LISP, C, and Prologue. Systran is written primarily in a proprietary machine language designed specifically for handling linguistic tasks. In addition, parts of some utility and system control programs are written in assembler. It is considered to be much faster than other systems. An additional factor in Systran's favor which led US government support for the Japanese-English translation project was, the fact that a Japanese firm called "IONA" had already invested considerable resources in developing the basic software needed for a Japanese to English system. This work is being conducted under a contract with a US company called LATSEC , the developer of Russian-English Systran. The US government has a licensing agreement with IONA and WTC which permits unlimited use of JESS for the production of translations for government use only by any agency of the US Government. The licence also permits limited distribution to the public of JESS translations by the Foreign Broadcast

Information Service (FBIS), the Office of Patent and Trademark (OPT) and the National Technical Information Service (NTIS). Since the US Government-sponsored work on JESS officially started in early 1986, LATSEC's work has been primarily directed at expanding the dictionary and acquiring the new input hardware, with limited linguistic work. The Intelligence Community hopes to have a prototype available in late 1988 to mid 1989.

In addition to this US Government sponsored project, MT research is being conducted at the Carnegie Melon University's (CMU) Center for Machine Translation under the direction of Prof. Jaime Carbonell and Masaru Tomita. They have developed an advanced multilingual translation system based on their the Universal Parser Architecture, which is an "Interlingua" approach. Unlike the transfer method mentioned earlier, the interlingua MT is designed to perform multi-lingual translation through a pivot language (interlingua). Any pair of translated languages must go through this pivot as opposed to direct transfer from one language to another. Currently the Universal Parser can handle Japanese, English and German simultaneously for sentences consisting of very limited and well defined vocabulary and grammar, It has also been tested for use in voice recognition or speech translation system. Not surprisingly, most of the funding for these activities at CMU is from Japanese corporations.

Other Japanese to English MT-related research activities have been reported by the Hunter College SUNY, Martin Marietta Corporation, and at the Courant Institute of Mathematical Sciences at New York University. Details of these efforts were not available at the time of this report.

**Japanese Activities on MT**

In contrast to the rather quiescent state of US efforts, the Japanese government views Japanese-English machine translation as an essential part of Japan's future, which they consider to be an information-based society. Beginning in 1982, ample funding has provided for the MU and MU-II projects for the development of a

suitable MT for translating JICST (Japanese Information Center for Science and Technology) abstracts. The MU project was a well developed and typically Japanese style cooperative research and development effort among industry (San) , government (Kan) and university(Gaku) . These MU and Mu-2 efforts have been led by Professor Nagao of Kyoto University, a father of Japanese MT research. Although funding from the Science and Technology Agency through MITI was 600 million yen or $4.8 million during 1982-86, the real cost of this venture was much larger (in the order of one billion yen or $ 8 million. Ten computer companies participated in this MU project by contributing researchers for a 4-year period to Prof. Nagao's laboratory. The cost allocation for the MU system was 50 % for the dictionary development, 20 % for the translation software development, and 10 % each for the linguists, evaluators, and hardware. Company researchers who participated in Prof. Nagao's MU project played central roles in the development of commercial as well as experimental MT systems, many of which were demonstrated at the MT "Summit Conference" held in Hakone, Japan in September, 1987. A brief summary of these products is contained in the attached Table 1. According to Prof. Nagao, currently over twenty companies in Japan are engaged in the development of commercial Japanese-English machine translation systems.

Currently the Japanese government continues to support several MT related projects, such as MU-II (to improve Mu by converting the original LISP program into more efficient C language program), Fifth Generation Computer System (ICOT), Electronic Dictionary Research projects (EDR, IPA), and CONTRAST of the Electro Technical Laboratory of MITI/AIST (Agency for Industrial Science and Technology). The Ministry of Posts and Telecommunication supports Automated Translation Telephone Research (ATR). Recently MITI initiated the CICC (Center for International Cultural Corporation) project to assist four neighboring countries in developing a pivot language for multi-lingual translation of Chinese, Thai, Malaysian and Indonesian. MITI is expected to allocate 6 billion yen ( $45 million) to develop a truly multi-lingual MT system centered around Japanese.

When completed, this advanced system could also be used to enhance Japanese-English translation technology.

Most commercial Japanese systems are produced in an integrated unit comprised of a company specific mini-computer, MT software, word processor, and input/output devices (inclusive of an optical character reader, or OCR for some systems), and are not available for software alone. An exception is one of the most commercialized systems called the Bravice system, originally developed by Weidner of the United States and later sold to a Japanese company. This is the only Japanese to English MT system available for personal computers (unfortunately not for the popular US made PC's but for popular Japanese PC's such as NEC 9800, IBM 5550, Toshiba). The Department of Computer Science at New York University is currently evaluating the Bravice system for US use with the NEC PC-9801, which is available in the USA.

Most commercial Japanese MT systems share a basic dictionary of 50,000 words supplemented by an additional dictionary of 200,000 to 250,000 technical words, which were developed by a private company. The translation speed is dependent upon the computer system, ranging from 60,000 words/hr of the main frame computer systems to 3000~5000 words/hr of the microcomputer based systems. The accuracy of their MT systems is generally claimed to be in the order of 70~80 % depending upon the complexity of the source document. With good pre-editing, some tasks showed an accuracy of over 90%.

Their MT systems have conversational editors and the ability to show on the split screen the source (Japanese) and the target (English) texts displayed side by side, making it easy to apply pre-and post editing to achieve the desired results. They are definitely a boon to professional translators, since the majority of technical terminologies are correctly and consistently translated by their technical dictionaries.

Most Japanese commercial MT systems use the transfer method, except for PIVOT of NEC and ATLAS of Fujitsu, which employ the

interlingua method ( It should be noted that definitions of these classifications differ. While Atlas-II claims to use an interlingua model, its published system descriptions refer to an transfer component). According to Prof. Nagao, the transfer method is suitable for conventional technical papers, business letters, manuals, etc, while the interlingual approach is more suitable for cases in which the source text is fragmented, incomplete, erroneous and non-grammatical requiring in-depth linguistic analysis. There are disagreements among Japanese MT developers as to the merit of the interlingua approach, which appears to be more powerful in incorporating contextual information and suitable for multi-lingual translation, yet is still considered somewhat over-theoretical.

Although many Japanese commercial systems appear impressive in demonstration, the true state of their accuracy is best described by Prof. M. Nagao as follows: "The companies selling machine translation systems are now being criticized by their customers for the poor quality of their translations and are agonizing over the difficulty of making significant improvements in their systems. It is an illusion for any MT system user to expect high quality results, unless the original text is carefully written to avoid ambiguity and misunderstanding." Prof. Nagao believes that an MT system can become a viable undertaking if one limits its application to

1. Daily news
2. User's manual for export/import merchandise
3. Abstracts
4. Drafts of conference memos
5. Drafts of stylized business letters

**European Activities for Japanese to English MT**

In England, there are two Japanese-English MT activities worth noting. The first is the AIDTRANS system of the Center for Japanese

Studies at Sheffield, based on a highly sophisticated and detailed analysis of Japanese grammar and the Integrated Dictionary System (IDS). The second system is the UMIST English-Japanese NTRAN system designed to permit technical authors of computer software manuals to read and write such texts in Japanese. As yet none of these English system are available for evaluation.

The European Community (CEC) currently has contracts with IONA (Systran) and Fujitsu (Atlas) for pilot projects to produce Japanese to English translations for the Community and is planning to incorporate Oki's optical character reader system.

**Conclusions and Recommendations**

Unlike Japan and the CEC countries, MT research in the United States has lagged due primarily to the devastating effects of the famous ALPAC (Automatic Language Processing Advisory Committee) report published in 1965. It is important to mention here that the MT research started in the United States before the 1950's. In 1954, IBM and Georgetown University developed an assembly language based machine translation system, a forerunner of Systran. The National Science Foundation spent nearly $20 million between 1955 and 65 on various MT projects. The progress was very slow, and after careful and exhaustive studies the ALPAC report conclusively recommended the termination of government support for MT activities by stating that the cost of developing viable MT systems to provide comparable translation done by human translators would be prohibitive (still a prevailing attitude within some circles). Since then US Government support for MT has been confined to US Air Force support of the Systran system, which was very effective in achieving over 90% accuracy for Russian to English translation.. However, Government-supported work on the Systran Japanese to English MT system (JESS) has not been significant yet and the system has not been made available for evaluation.

On the other hand, the Japanese has made impressive progress in developing commercial MT systems, which appear adequate for

translating so called "minimum Japanese" into "minimum English". In other words, the translated results of technical documents prepared with rigid formats and grammar, such as user's manuals and service manuals for machinery and electronic instruments, are easily understood by readers familiar with the subject matter. There is no doubt that the Japanese will keep improving their systems so that acceptable quality MT systems will be made available at low cost.

Except for the direct data base search through electronic communication systems, current Japanese MT systems, however, are still useless for the majority of American engineers and scientists who are unable to input Japanese texts onto the keyboard. An optical character reading (OCR) system to read Japanese text including charts, figures and tables is mandatory. Several Japanese companies, such as Fuji Electric, Ricoh, Sanyo, Fujitsu, Matsushita, Sony and Oki Electric, are currently marketing or planning to market OCR systems ( see Table 2). Most systems have the capability to read different size fonts in vertical as well as horizontal sentences. Some systems under development can even read handwritten Japanese text. The speed of character recognition varies from 2 characters per second to 30 characters per second depending upon the nature of font with a claimed recognition accuracy of over 99%. The prices of their OCR's are, however, rather high ranging from Matsushita's $ 6200 to Fuji' Electric's $37,000. Oki and Fujitsu are said to be planning to market an integrated OCR-MT system by Sept. 1988.

It is recommended that these Japanese accomplishments be evaluated critically by competent US experts on MT /OCR to see if some of their commercial systems can be adopted or made use of in the US. There is a crucial need to expedite the use of MT by US engineers and scientists who want quick assessments of the technical content of Japanese literature without going through the costly, time-consuming, and not necessarily useful process of full translation.

## Table 1: Japanese to English Machine Translation Available in Japan

(Information available as of Sept. 1987)

| Name / Company | Computer/ Language Connection | Dictionaries Common/Technical | Speed Words/hour | OCR |
|---|---|---|---|---|
| Atlas-II Fujitsu | Facom M/C | 50,000/250,000 | 60,000 | Yes |
| HIGHCATS Hitachi | HITAC/PL1 | 50,000/250,000 | 60,000 | No |
| TAURAS Toshiba | UNIX/C | 50,000/50,000 | 7,000 | No |
| SWP-7800 Sanyo | iRMX/C | 50,000/55,000 | 3,500 | Yes |
| PENSEE Oki | UNIX/C | 60,000/40,000 | 4,000 | Yes |
| PIVOT NEC | ACOS/ | 60,000 | | No |
| MELTRAN Mitsubishi | SIMPOS/ESP | 50,000/30,000 | 5,000 | No |
| LAMB Cannon | Symbolics/LISP | 2,000 | 1,000 | No |
| PAROLE Matsushita | General/Prolog | 5,000 | | |
| MicroPack Bravice | Japanese PC's | 70,000/30,000 | 2,000 | No |
| MU Kyoto Univ. | FACOM/LISP | 300,000 | 4,000 | No |
| RMT | AT7T 382/C | 30,000 | 4,500 | No |
| Systran IONA | Facom/Assembler | 40,000/* 1,000,000 | 300,000 to | No |

* Efforts are underway to incorporate the Inter-Press science and Technology data bases of 250,000 terms.

## Table 2: Japanese Commercial OCR Systems

(Information available as of July 1988)

| Name /Company | Computer | Recognition speed, ch/s | Recognizable Number | Characters Size (mm) | Price 1000 yen |
|---|---|---|---|---|---|
| Sanyo/CCL-3300K | PC9801 | 5 | 3250 | 2 | 1980 |
| Fuji Elec./XP-505 | FMR-60/70 | 30 | 4000 | 2.5-9.8 | 4670 |
| Matsushita | M500/700 | 8 | 3210 | 3.0-32 | 776 |
| Fujitsu /F6365 | FACON/G100 | 20 | 3500 | 2.5-9.8 | 4170 |
| Ricoh/R365 | PC9801 | 9 | 3242 | 3.5-10 | N/A |
| SONY | NEWS | 100 | 3400 | 2 | N/A |

## Bibliography

Following publications were useful in the preparation of this paper:


1. Appendix 5, "Machine Translation" , Report to Congress "Activities of the Federal Government to Collect, Abstract, Translate and Distribute Declassified Japanese Scientific and Technical Information 1987-1988", PB88-194816, Office of Japanese Technical Literature, US Department of Commerce, 1988.

2. MT Summit, Manuscript and Program, Japan Electronic Industry Development Association, September 17-19, 1987.

3. David B. Shonyo and Janet H. Geffner," The Supply and Use of Japanese Technical Information in the United States", National Technical Information Service, 1988.

4. Program of the Second International Conference on Theoretical and Methodological Issues in Machine Translation of Natural Languages, June 12-14, 1988, Center for Machine Translation, Carnegie Mellon University.

5. Carol Pearson "Moving Beyond Vodka and Rotten Meat" Carnegie Mellon Magazine, Vol.6 No.3, Spring, 1988, pp 14-19.

6. Sergei Nirenburg, "Machine Translation", Cambridge University Press, 1987.

7. Jon Sigurdson and Roger Greatrex, "Machine Translation of On-Line Searches in Japanese Databases", The Research Policy Institute, Lund University, Sweden, 1987.

8. Makoto Nagao, " To What Extent Is Machine Translation Possible?" Iwanami Book Co. 1986 (in Japanese).

9. Private communication with Mr. Tatsuo Ashizaki, Chief, Machine Translation Section, Japan Information Center for Science and Technology.

10. Private communication with Ms. Chuck Walrad of Systran Corporation.

UNITED STATES DEPARTMENT OF COMMERCE
The Under Secretary for Technology
Washington, D.C. 20230

MAY 12 1989

Honorable Doug Walgren
Chairman, Subcommittee on Science,
Research and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

As required by the Omnibus Trade and Competitiveness Act of 1988, I am submitting an organization plan for the National Institute of Standards and Technology. The Act renamed the National Bureau of Standards as the National Institute of Standards and Technology (NIST) and directed that a new organization plan be submitted to the Congress. As specified in the Act, the organization plan establishes the major operating units of the Institute, maintains the ongoing programs of the Institute, and provides for the new responsibilities including the Advanced Technology Program and the Inventions Program.

This organization plan retains the existing four technical major operating units with only minor modifications to provide close coordination among technology disciplines and adds a new major operating unit, Technology Services. The Advanced Technology Program is in the Office of the Director of Technology Services. In general, the functions related to technology transfer and industrial services are assigned to Technology Services and functions related to research and technology development are assigned to the NIST technical laboratories.

The Visiting Committee on Advanced Technology has reviewed the organization plan and they concur with the creation of the Technology Services to fulfill the additional legislative requirements of the Act. They also concur with proposed modifications in the National Measurement Laboratory and in the National Engineering Laboratory, which consist of combining a few technical areas and in consolidating competences to improve the quality and effectiveness of the research and development needed by U.S. industry. The organization plan has been approved by the Department of Commerce and by the Office of Management and Budget.

The NIST Congressional Liaison Officer, Esther C. Cassidy, will be pleased to help you if you require additional information. She may be reached at 975-3080.

Sincerely,

Lee W. Mercer
Deputy Under Secretary
for Technology

Enclosures

cc: Honorable Sherwood Boehlert

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Organization Plan

I. Explanation of Proposed Change

The National Institute of Standards and Technology proposes to reorganize because of an expanded mission resulting from passage of the Omnibus Trade and Competitiveness Act of 1988. This proposed reorganization retains the existing four technical major operating units with only minor modifications to provide closer coordination among technology disciplines and adds a new major operating unit, Technology Services which includes the Advanced Technology Program and the Inventions Program. Functions related to technology transfer and industrial services are assigned to Technology Services and functions related to research and technology development are assigned to the NIST technical laboratories.

II. Objective

The objective of the reorganization is to structure the Institute to augment its ability to enhance the competitiveness of American industry while maintaining its traditional function as the lead national laboratory for providing the measurements, calibrations, and quality assurance techniques which underpin the United States' commerce, technological progress, improved product reliability and manufacturing processes, and public safety.

III. Effect on Functions or Authority

The new structure results from changes in legislation, delegations of authority, and program content but requires no further changes in functions or authority for successful implementation.

IV. Budgetary Impact

The organizational structure for the Technology Services portion of this reorganization, based on Trade Act responsibilities, reflects the minimum program needed to carry out these functions. This portion of the reorganization is not contingent upon any particular funding level.

No increased costs are expected to accrue for the other portions of this reorganization.

98-198 0 - 89 - 26

V. Expected Improvements in the Delivery of Services and in the Performance of Agency Missions.

The proposed reorganization is intended to improve the NIST capacity to serve the user community primarily in two ways. First, the plan combines technical areas and consolidates competences to improve the quality and effectiveness of the research and technical development needed by United States industry. Second, a new organizational unit, Technology Services, is added to expand services to industry.

VI. Proposed Timing of Implementation

The target date for implementation is June 26, 1989.

VII. Implementation Mechanism

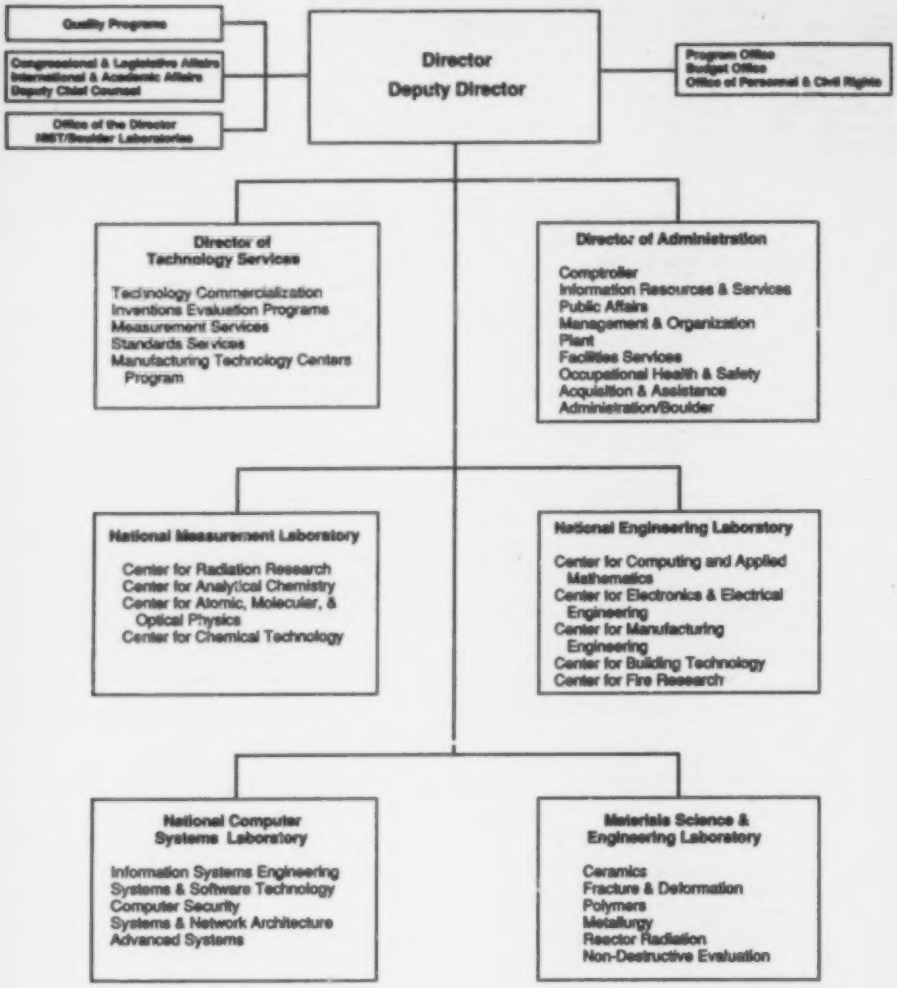
The Department of Commerce's implementation mechanism is the issuance of Department Organization Order 30-2B which specifies the organization of NIST and the assignment of functions within that organization.

VIII. Organizational Charts

Enclosed are charts for the current and proposed organizational structure and a crosswalk showing the connections between them.

PROPOSED
DOO 30-2B

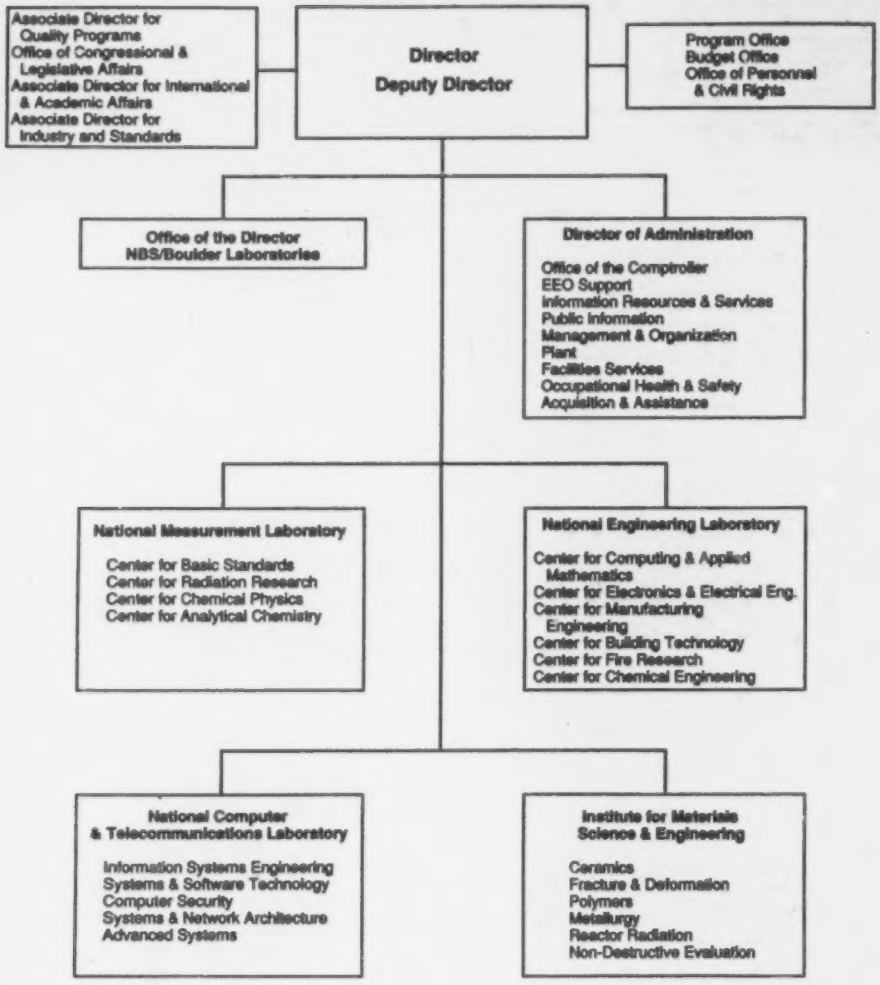
## U.S. DEPARTMENT OF COMMERCE
## National Institute of Standards and Technology



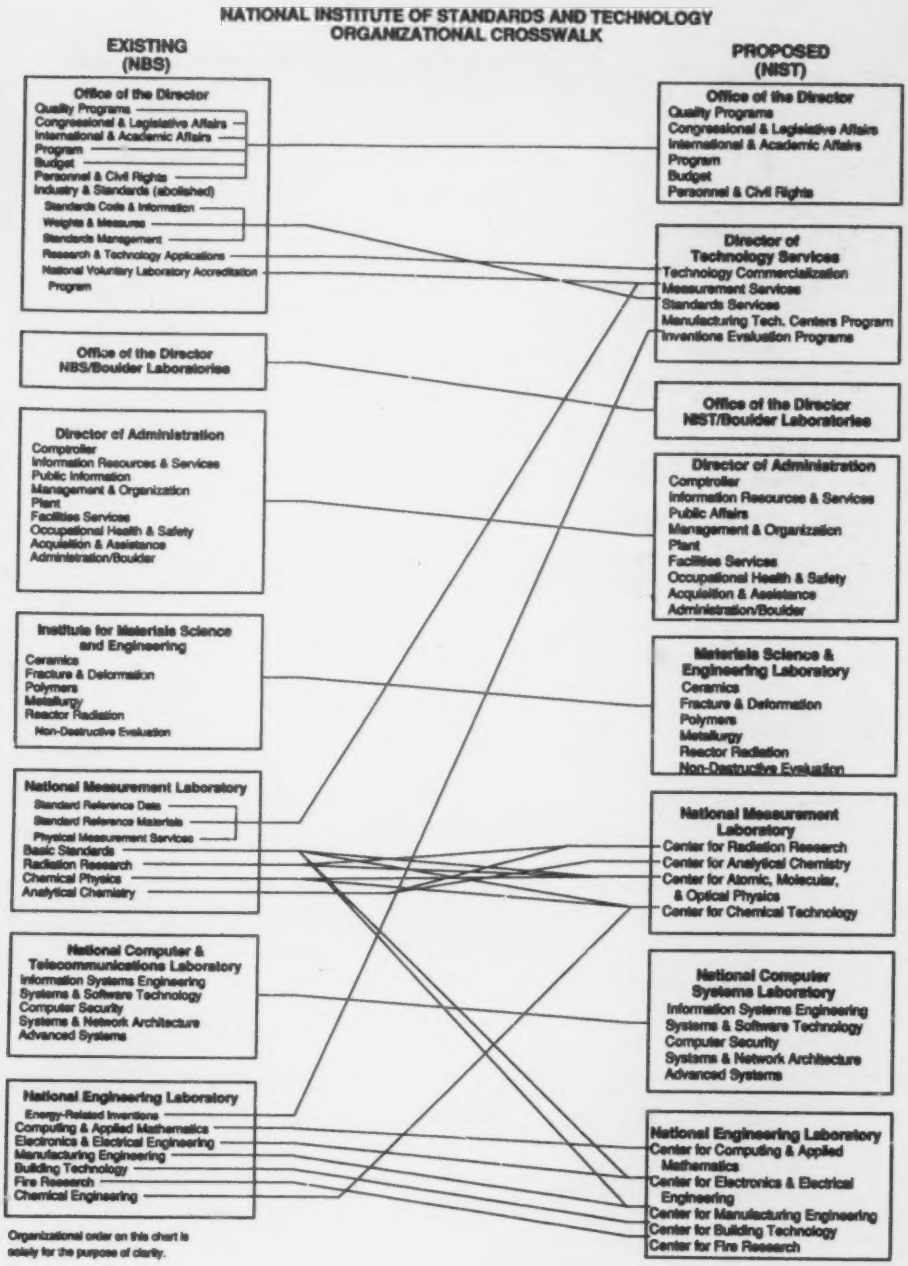
CURRENT

DOO 30-2B

## U.S.DEPARTMENT OF COMMERCE
## National Bureau of Standards




August 22, 1988


NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
ORGANIZATIONAL CROSSWALK
EXISTING (NBS)
PROPOSED (NIST)
Office of the Director
Quality Programs
Congressional & Legislative Affairs
International & Academic Affairs
Program
Budget
Personnel & Civil Rights
Industry & Standards (abolished)
Standards Code & Information
Weights & Measures
Standards Management
Research & Technology Applications
National Voluntary Laboratory Accreditation Program
Office of the Director
NBS/Boulder Laboratories
Director of Administration
Comptroller
Information Resources & Services
Public Information
Management & Organization
Plant
Facilities Services
Occupational Health & Safety
Acquisition & Assistance
Administration/Boulder
Institute for Materials Science and Engineering
Ceramics
Fracture & Deformation
Polymers
Metallurgy
Reactor Radiation
Non-Destructive Evaluation
National Measurement Laboratory
Standard Reference Data
Standard Reference Materials
Physical Measurement Services
Basic Standards
Radiation Research
Chemical Physics
Analytical Chemistry
National Computer & Telecommunications Laboratory
Information Systems Engineering
Systems & Software Technology
Computer Security
Systems & Network Architecture
Advanced Systems
National Engineering Laboratory
Energy-Related Inventions
Computing & Applied Mathematics
Electronics & Electrical Engineering
Manufacturing Engineering
Building Technology
Fire Research
Chemical Engineering
Organizational order on this chart is solely for the purpose of clarity.
Office of the Director
Quality Programs
Congressional & Legislative Affairs
International & Academic Affairs
Program
Budget
Personnel & Civil Rights
Director of Technology Services
Technology Commercialization
Measurement Services
Standards Services
Manufacturing Tech. Centers Program
Inventions Evaluation Programs
Office of the Director
NIST/Boulder Laboratories
Director of Administration
Comptroller
Information Resources & Services
Public Affairs
Management & Organization
Plant
Facilities Services
Occupational Health & Safety
Acquisition & Assistance
Administration/Boulder
Materials Science & Engineering Laboratory
Ceramics
Fracture & Deformation
Polymers
Metallurgy
Reactor Radiation
Non-Destructive Evaluation
National Measurement Laboratory
Center for Radiation Research
Center for Analytical Chemistry
Center for Atomic, Molecular, & Optical Physics
Center for Chemical Technology
National Computer Systems Laboratory
Information Systems Engineering
Systems & Software Technology
Computer Security
Systems & Network Architecture
Advanced Systems
National Engineering Laboratory
Center for Computing & Applied Mathematics
Center for Electronics & Electrical Engineering
Center for Manufacturing Engineering
Center for Building Technology
Center for Fire Research

Reply/SRT

UNITED STATES DEPARTMENT OF COMMERCE
The Deputy Under Secretary for Technology
Washington, D.C. 20230

MAY 19 1989

Honorable Robert A. Roe
Chairman, Subcommittee on Science,
Space, and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Budget estimates for fiscal years 1990 to 1992 for the National Institute of Standards and Technology are contained in the table attached to this letter. Administration policy requires that multi-year planning estimates of Presidential policy be consistent with the budget year request, in this case FY 1990, and indicate which specific policy decisions made for the budget year affect multi-year planning levels. Accordingly, the budget estimate for fiscal year 1990 is consistent with the President's budget, including proposed program changes. Estimates for fiscal years 1991 and 1992 are based upon the policy decisions contained in the FY 1990 request, and reflect incremental outyear requirements based on the FY 1990 budget, as well as OMB allowances for inflation and planned management savings.

The review of the FY 1991 budget is now underway and the results of this review will appear in the President's 1991 budget.

The NIST Congressional Liaison Officer, Esther C. Cassidy, will be pleased to help if you require additional information. She may be reached on 975-3080.

Sincerely,

Lee W. Mercer
Deputy Under Secretary
for Technology

Enclosure

cc: Honorable Robert S. Walker

National Institute of Science & Technology
Scientific and Technical Research and Services
Three Year Budget
(Dollars in thousands)

| Subactivity | FY 1990 Perm Pos | FY 1990 BA | FY 1991 Perm Pos | FY 1991 BA | FY 1992 Perm Pos | FY 1992 BA | Total 3-Year Cumulative Program Change Perm Pos | Total 3-Year Cumulative Program Change BA |
|---|---|---|---|---|---|---|---|---|
| Measurement Research & Stds | 469 | 44,435 | 446 | 44,993 | 446 | 45,363 | | |
| Chemical Measurements & Stds | [16] | [2,100] | [0] | [0] | [0] | [0] | [16] | [2,100] |
| Materials Science & Engineering | 259 | 24,418 | 248 | 24,728 | 248 | 24,932 | | |
| High Performance Composites | [10] | [1,000] | [0] | [0] | [0] | [0] | [10] | [1,000] |
| Engineering Measurements & Stds | 500 | 43,102 | 450 | 42,976 | 450 | 43,355 | | |
| Lightwave Measurement Technology | [30] | [2,600] | [0] | [0] | [0] | [0] | [30] | [2,600] |
| High Temperature Superconductors 1/ | [8] | [700] | [-26] | [-700] | [0] | [0] | [-26] | [0] |
| Bioprocess Engineering | [29] | [2,300] | [0] | [0] | [0] | [0] | [29] | [2,300] |
| Fire and Safety Research | [-49] | [-3,872] | [0] | [0] | [0] | [0] | [-49] | [-3,872] |
| New Fire Research on Ignition of Upholstery & Toxicity Studies | [-3] | [-250] | [0] | [0] | [0] | [0] | [-3] | [-250] |
| Study of Alternative Refrigerants | [-3] | [-250] | [0] | [0] | [0] | [0] | [-3] | [-250] |
| Computer Sciences & Technology | 172 | 13,043 | 165 | 13,217 | 165 | 13,344 | | |
| Computer Security | [41] | [3,500] | [0] | [0] | [0] | [0] | [41] | [3,500] |
| Industrial Technology Services | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Industrial Technology Grants | [-8] | [-7,500] | [0] | [0] | [0] | [0] | [-8] | [-7,500] |
| Center for Integrated Design, Non-Destructive Evaluation & Mfg. | [0] | [-7,500] | [0] | [0] | [0] | [0] | [0] | [-7,500] |
| Evaluation of Non-Energy Related Inventions | [-1] | [-150] | [0] | [0] | [0] | [0] | [-1] | [-150] |
| Research Support Activities | 251 | 30,611 | 239 | 32,208 | 239 | 32,629 | | |
| Scientific Computing Upgrade | [0] | [3,122] | [0] | [1,311] | [0] | [227] | [0] | [4,660] |
| Total, National Institute of Standards and Technology | 1,651 | 155,609 | 1,548 | 158,122 | 1,548 | 159,623 | | |
| [Cumulative Program Change] | [70] | [-4,200] | [-26] | [611] | [0] | [227] | [44] | [-3,362] |

1/ NIST High Temperature Superconducting Program to be reviewed prior to President's FY 1991 budget to Congress.

SRT

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Administration
Washington, D.C. 20230

MAY 19 1989

MAY 22 1989

Honorable Neal Smith
Chairman, Subcommittee on Commerce,
Justice, State, the Judiciary
and Related Agencies
Committee on Appropriations
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

The purpose of this letter is to notify you of three FY 1989 reprogrammings for the National Institute of Standards and Technology (NIST).

Two reprogrammings result from the enclosed NIST reorganization plan. The first proposes to combine technical areas and consolidate competence to improve the quality and effectiveness of the research and development needed by U.S. industry. The second proposes to combine technology transfer and industrial services to expand services to industry. This reorganization plan is also being submitted to the Commerce, Science and Transportation and the Science, Space and Technology Committees pursuant to the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418).

The third reprogramming which is not related to the reorganization proposes to use a portion of the FY 1988 unobligated balances intended for support to the Regional Centers for the Transfer of Manufacturing Technology to fund the preparation of various important reports and studies mandated in the Technology Competitiveness Act.

Please contact me or my staff if you have any questions.

Sincerely,

Otto J. Wolff
Acting Assistant Secretary
for Administration

Enclosures

cc: Honorable Harold Rogers
Honorable Robert Roe
Honorable Robert S. Walker
Honorable Doug Walgren
Honorable Sherwood Boehlert

DEPARTMENT OF COMMERCE

Notice of Proposed Reprogramming

FY 1989

Operating Unit: National Institute of Standards and Technology
Appropriation: Scientific and Technical Research and Services
Activity: Measurement and Engineering Research and Standards

FISCAL SUMMARY

(Amount in thousands of dollars)

| | Perm. Pos. | Amount |
|---|---|---|
| 1. Reprogrammed from: | | |
| Industrial Technology Services | | |
| Industrial technology services (Grants) | ... | -$650 |
| 2. Reprogrammed to: | | |
| Industrial Technology Services | | |
| Industrial technology services (Operations) | ... | +$650 |

Description/Justification

- Request reprogramming of $650K from the unobligated balances intended for support to the Regional Centers for the Transfer of Manufacturing Technology in order to fund the preparation of various important reports and studies mandated in the Technology Competitiveness Act. These reports include a report on a plan to make small business more aware of NIST; a contract with the National Academies of Science and Engineering to study government-private cooperative research and technology transfer; a report on State Technology Extension services and the implementation plan to provide assistance to the states; a Federal Register notice outlining criteria for selection of recipients of assistance under the Advanced Technology Program; an implementation plan for establishment of a Non-Energy Related Inventions Program based upon the Energy Related Inventions Program as a model; and a report on policies and budget proposals in semiconductor manufacturing, fiber optics, superconducting materials and advanced manufacturing. Progress on these studies and reports has been identified as topics of interest to Congressional committees during budget hearings.

Effects

- This reprogramming will allow NIST to fund the Manufacturing Technology Centers at a slightly lower level and at the same time comply with the other requirements of the legislation. Without reprogramming, NIST will be unable to complete these assignments.

DEPARTMENT OF COMMERCE

Notice of Proposed Reprogramming (Reclassification)

FY 1989

Operating Unit: National Institute of Standards and Technology
Appropriation: Scientific and Technical Research and Services
Activity: Measurement and Engineering Research and Standards

FISCAL SUMMARY

(Amount in thousands of dollars)

| | Perm. Pos. | Amount |
|---|---|---|
| 1. Reprogramming (reclassification) from: | | |
| Measurement and Engineering Research and Standards | | |
| Measurement research and standards | | |
| Radiation measurements and standards | -48 | -$3,621 |
| Engineering measurements and standards | | |
| Chemical engineering metrology | -65 | -5,436 |
| 2. Reprogramming (reclassification) to: | | |
| Measurement and Engineering Research and Standards | | |
| Measurement research and standards | | |
| Fundamental physical measurements and standards | +35 | +2,347 |
| Chemical properties and processes | +62 | +5,224 |
| Engineering measurements and standards | | |
| Electronics and electrical measurements | +11 | +1,026 |
| Manufacturing research and standards | +5 | +460 |

Description/Justification

As part of the reorganization plan, NIST proposes to combine technical areas and consolidate competences to improve the quality and effectiveness of the research and technical development needed by United States Industry. This reorganization requires the reclassification of budgetary resources as indicated in the fiscal summary section above.

Effects

The proposed reclassification will result in a closer alignment of the NIST organizational and budgetary structures and facilitate a more efficient mechanism to describe NIST research programs. The content and level of the specific research efforts will not be affected.

DEPARTMENT OF COMMERCE

Notice of Proposed Reprogramming (Reclassification)

FY 1989

Operating Unit: National Institute of Standards and Technology
Appropriation: Scientific and Technical Research and Services
Activity: Measurement and Engineering Research and Standards

FISCAL SUMMARY

(Amount in thousands of dollars)

| | Perm. Pos. | Amount |
|---|---|---|
| 1. Reprogramming (reclassification) from: | | |
| Measurement and Engineering Research and Standards | | |
| Measurement research and standards | | |
| Measurement technology transfer | -49 | -$4,352 |
| Research support activities | | |
| Product standards | -43 | -2,918 |
| 2. Reprogramming (reclassification) to: | | |
| Measurement and Engineering Research and Standards | | |
| Industrial technology support | +92 | +7,270 |

Description/Justification

As part of the reorganization plan, NIST proposes to combine technology transfer and industrial services to expand services to industry. This reorganization requires the reclassification of budgetary resources as indicated in the fiscal summary section above.

Effects

The proposed reclassification will result in a closer alignment of the NIST organizational and budgetary structures and facilitate a more efficient mechanism to describe NIST programs. The content and level of the specific technical activities will not be affected.

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Organization Plan

I. Explanation of Proposed Change

The National Institute of Standards and Technology proposes to reorganize because of an expanded mission resulting from passage of the Omnibus Trade and Competitiveness Act of 1988. This proposed reorganization retains the existing four technical major operating units with only minor modifications to provide closer coordination among technology disciplines and adds a new major operating unit, Technology Services which includes the Advanced Technology Program and the Inventions Program. Functions related to technology transfer and industrial services are assigned to Technology Services and functions related to research and technology development are assigned to the NIST technical laboratories.

II. Objective

The objective of the reorganization is to structure the Institute to augment its ability to enhance the competitiveness of American industry while maintaining its traditional function as the lead national laboratory for providing the measurements, calibrations, and quality assurance techniques which underpin the United States' commerce, technological progress, improved product reliability and manufacturing processes, and public safety.

III. Effect on Functions or Authority

The new structure results from changes in legislation, delegations of authority, and program content but requires no further changes in functions or authority for successful implementation.

IV. Budgetary Impact

The organizational structure for the Technology Services portion of this reorganization, based on Trade Act responsibilities, reflects the minimum program needed to carry out these functions. This portion of the reorganization is not contingent upon any particular funding level.

No increased costs are expected to accrue for the other portions of this reorganization.

V. Expected Improvements in the Delivery of Services and in the Performance of Agency Missions.

The proposed reorganization is intended to improve the NIST capacity to serve the user community primarily in two ways. First, the plan combines technical areas and consolidates competences to improve the quality and effectiveness of the research and technical development needed by United States industry. Second, a new organizational unit, Technology Services, is added to expand services to industry.

VI. Proposed Timing of Implementation

The target date for implementation is June 26, 1989.

VII. Implementation Mechanism

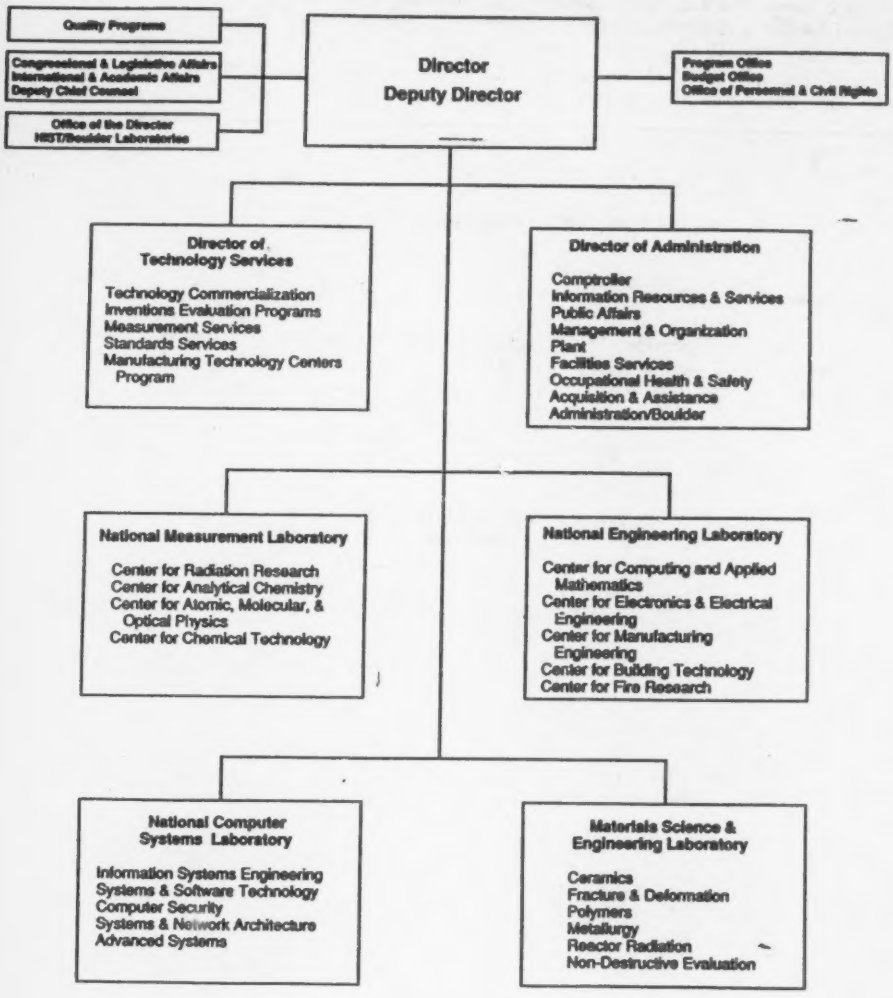
The Department of Commerce's implementation mechanism is the issuance of Department Organization Order 30-2B which specifies the organization of NIST and the assignment of functions within that organization.

VIII. Organizational Charts

Enclosed are charts for the current and proposed organizational structure and a crosswalk showing the connections between them.

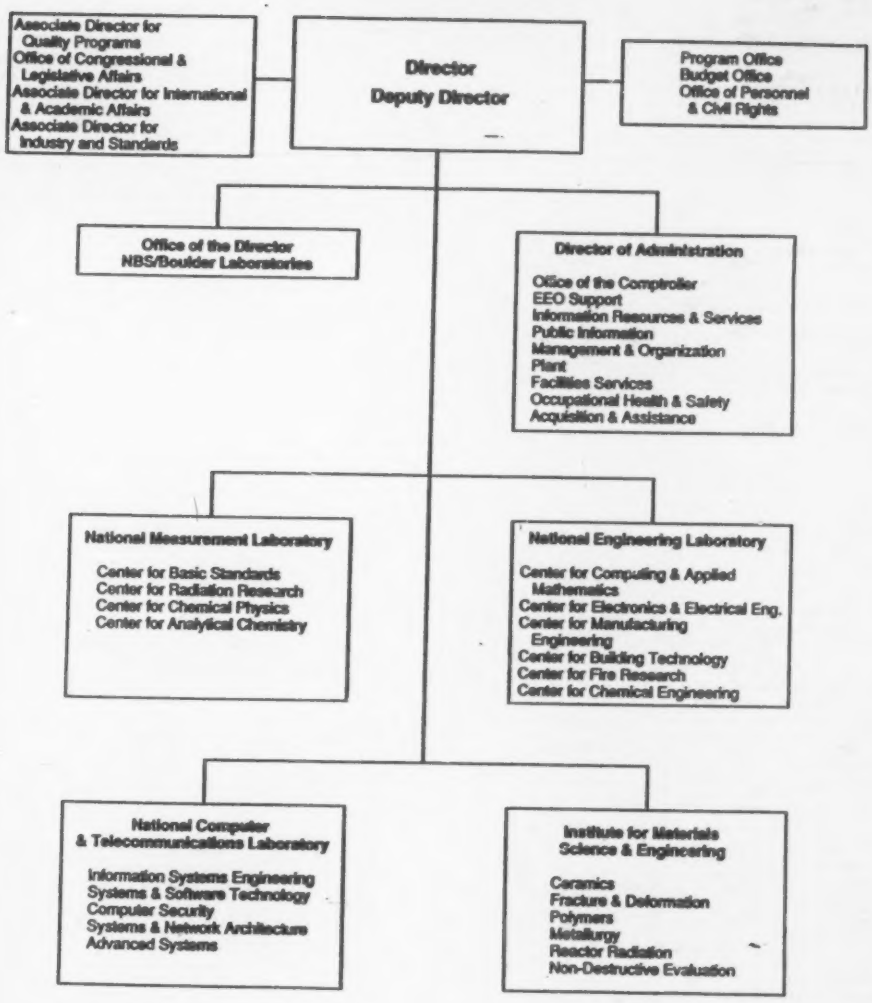
PROPOSED
DOO 30-2B

# U.S.DEPARTMENT OF COMMERCE
## National Institute of Standards and Technology

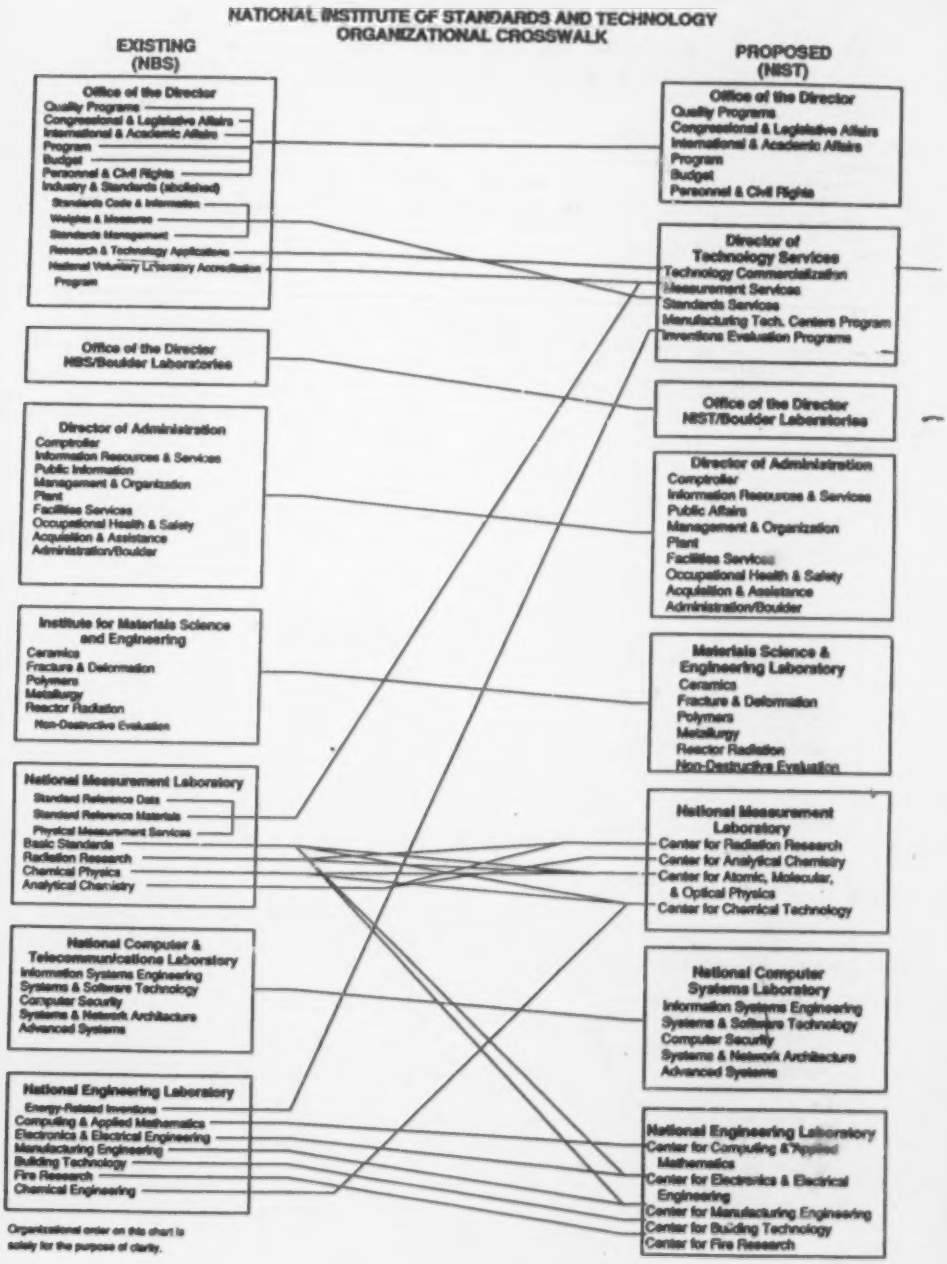


**U.S.DEPARTMENT OF COMMERCE**
**National Bureau of Standards**

CURRENT
DOO 30-2B




August 22, 1988


NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
ORGANIZATIONAL CROSSWALK
EXISTING
(NBS)
PROPOSED
(NIST)
Office of the Director
Quality Programs
Congressional & Legislative Affairs
International & Academic Affairs
Program
Budget
Personnel & Civil Rights
Industry & Standards (abolished)
Standards Code & Information
Weights & Measures
Standards Management
Research & Technology Applications
National Voluntary Laboratory Accreditation Program
Office of the Director
NBS/Boulder Laboratories
Director of Administration
Comptroller
Information Resources & Services
Public Information
Management & Organization
Plant
Facilities Services
Occupational Health & Safety
Acquisition & Assistance
Administration/Boulder
Institute for Materials Science and Engineering
Ceramics
Fracture & Deformation
Polymers
Metallurgy
Reactor Radiation
Non-Destructive Evaluation
National Measurement Laboratory
Standard Reference Data
Standard Reference Materials
Physical Measurement Services
Basic Standards
Radiation Research
Chemical Physics
Analytical Chemistry
National Computer & Telecommunications Laboratory
Information Systems Engineering
Systems & Software Technology
Computer Security
Systems & Network Architecture
Advanced Systems
National Engineering Laboratory
Energy-Related Inventions
Computing & Applied Mathematics
Electronics & Electrical Engineering
Manufacturing Engineering
Building Technology
Fire Research
Chemical Engineering
Organizational order on this chart is solely for the purpose of clarity.
Office of the Director
Quality Programs
Congressional & Legislative Affairs
International & Academic Affairs
Program
Budget
Personnel & Civil Rights
Director of Technology Services
Technology Commercialization
Measurement Services
Standards Services
Manufacturing Tech. Centers Program
Inventions Evaluation Programs
Office of the Director
NIST/Boulder Laboratories
Director of Administration
Comptroller
Information Resources & Services
Public Affairs
Management & Organization
Plant
Facilities Services
Occupational Health & Safety
Acquisition & Assistance
Administration/Boulder
Materials Science & Engineering Laboratory
Ceramics
Fracture & Deformation
Polymers
Metallurgy
Reactor Radiation
Non-Destructive Evaluation
National Measurement Laboratory
Center for Radiation Research
Center for Analytical Chemistry
Center for Atomic, Molecular, & Optical Physics
Center for Chemical Technology
National Computer Systems Laboratory
Information Systems Engineering
Systems & Software Technology
Computer Security
Systems & Network Architecture
Advanced Systems
National Engineering Laboratory
Center for Computing & Applied Mathematics
Center for Electronics & Electrical Engineering
Center for Manufacturing Engineering
Center for Building Technology
Center for Fire Research

NIST Bond

UNITED STATES DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
(Formerly National Bureau of Standards)
Gaithersburg, Maryland 20899
OFFICE OF THE DIRECTOR

MAY 16 1988

Honorable Doug Walgren
Chairman, Subcommittee on Science,
Research and Technology
Committee on Science, Space and
Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The Section 5163 (b) of the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418) directs the National Institute of Standards and Technology (NIST) to prepare a plan detailing how it will make small businesses more aware of its activities and the manner in which NIST will seek to increase the application of its research, particularly in manufacturing, by small businesses. I am enclosing a copy of our report addressing these points.

The NIST maintains a variety of outreach programs that have been very effective in making small businesses aware of its research and development activities, and that have resulted in the transfer of technology developed by the Institute. These outreach programs include our Research Associate and Guest Worker Programs, our Cooperative Research Agreements, our Small Business Innovation Research Program, and our Energy-Related Inventions Program.

The NIST continues to actively work to reach more small businesses, and we are exploring new opportunities. We are already working with the Federal Laboratory Consortium, the Association of Small Business Development Centers, the National Governors' Association, and other organizations to provide linkages with State technical assistance efforts. Such interaction with State and nationally focused programs will lead to greater outreach to small businesses.

If you have any questions or would like additional information, our Congressional Affairs Director, Esther Cassidy, will be pleased to assist you. She can be reached at 975-3080.

Sincerely,

Raymond

Raymond G. Kammer
Acting Director

Enclosure

cc: Honorable Sherwood L. Boehlert

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U.S. DEPARTMENT OF COMMERCE

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

INDUSTRIAL TECHNOLOGY SERVICES

# COOPERATION WITH SMALL BUSINESSES

DECEMBER 1988

## NIST COOPERATION WITH SMALL BUSINESSES

Background

Section 5163 (b) of the Omnibus Trade and Competitiveness Act directs the Institute to prepare a plan detailing how it will make small businesses more aware of its activities; how it will attempt to increase small businesses' participation in the Institute's research and technology transfer programs; and how it will apply the Institute's research to small businesses, particularly in manufacturing.

There are other provisions of the Trade Act that relate to cooperation with small businesses and that require initiatives to be taken that also address most of the questions posed above. These are as follows:

Section 2151 (a) Technology Centers and Technology Assistance, requires NIST to establish and support Regional Centers for the Transfer of Manufacturing Technology.

Under the Technology Assistance part of Section 2151 (a), NIST is directed to work with State technology programs throughout the United States to help those programs help businesses, particularly small- and medium-sized businesses, to enhance their competitiveness through application of science and technology.

Section 2151 (b) Technology Extension Services, requires the Secretary of Commerce to conduct a nationwide study of current State technology extension services; to produce a report to Congress on the results of the study; and to provide an implementation plan for providing assistance to the States which will address methods by which the States can, in cooperation with Federal agencies, increase the use of Federal technology by businesses within their States to improve industrial competitiveness.

Section 2151 (d) Non-Energy Inventions Program, authorizes a program for the evaluation of inventions that are not energy-related to complement the Energy-Related Inventions Program established in 1974 under P.L. 93-577.

This submission addresses only section 5163 (b) of the Act as regards activities within NIST to make small businesses aware of its research and development activities, and to encourage such businesses to take advantage of opportunities for cooperative research and development programs. The additional requirements on NIST contained in sections 2151 (a) and (b) of the Act will be the subject of separate submissions per the Act.

Existing Activities with Small Businesses

NIST maintains a variety of outreach programs that have been very effective in making small businesses aware of its research and development activities, and that have resulted in the transfer of technology developed by the Institute. Examples include the following:

Research Associate Program - NIST has had a formal Research Associate Program since 1921. During FY88, there were 185 industrial researchers at

the Institute doing collaborative work with their peers in NIST. About 35% of the research associates were from small businesses. Over the past several years there have been 41 research associates in the Automated Manufacturing Research Facility. Fourteen of these associates, or 34%, have come from small businesses. The Research Associate Program is a cost efficient and effective way for NIST and industry to form partnerships on research projects of mutual interest. Industry benefits by getting access to facilities and expertise it may not otherwise enjoy. NIST gains high quality additional research talent at almost no cost while at the same time gaining an important perspective on its industrial partners.

Guest Researcher Program - Similar to the Research Associate Program, NIST permits scientists and engineers from universities and other public and private organizations to spend time at the Institute pursuing individual research objectives within the scope of NIST's ongoing programs. IN FY88, there were some 900 guest researchers in the Program. Though this program is not aimed at small businesses, it is nevertheless an effective means of technology transfer to university programs that support business activities within their states. Similar to the Guest Researcher Program, NIST operates a Proprietary Research Program whereby businesses are permitted to use unique measurement and test facilities located at the Institute to conduct proprietary research. The Program provides industry access to world-class test facilities not available in the private sector and is very cost effective to businesses desiring to use such facilities to conduct proprietary tests. A publication describing NIST's measurement and test facilities is attached.

Cooperative Research Agreements - In addition to the two programs mentioned above, NIST currently has about 250 cooperative research projects with industry, government, and the universities. 24% of these projects involve small businesses or consortia of small businesses. Most of these cooperative agreements are oriented to assisting industry in quickly adapting new technology in manufacturing, in industrial processes, and in developing the associated measurement means and methods for controlling the quality of resulting products. NIST research in emerging technologies like advanced materials, microelectronics, automation, biotechnology, and thin layer technologies, is driven by the need to develop measurement standards and methods that industry must have to properly understand and measure the properties and performance characteristics of materials and processes. Such standards and measurement methods are critical in applying new advances in materials, in manufacturing, and in industrial processes.

Small Business Innovation Research Program - NIST is very active in the DOC SBIR program and during FY88 advertised some 35 research topics for bid by small businesses. Institute staff participated in the Federal High Technology Conferences in Philadelphia and in Phoenix which were attended by more than 1,100 small businesses having interest in agency SBIR Programs.

Energy Related Inventions Program - The NIST Office of Energy-Related Inventions has been conducting an outreach program, aimed at individual inventors and small businesses with energy-related inventions for the past decade. To date, the 25,000 inventions submitted to OERI have come from

individual inventors or from small businesses. OERI has also developed a computerized system for tracking returns from various outreach efforts using serialized application forms. In addition to OERI's valuable experience in dealing with a range of technology transfer issues of concern to small business and its National Innovation Workshop program (forty-eight workshops around the country in the past eight years), OERI has recently signed a cooperative agreement with the Association of Small Business Development Centers to strengthen its outreach efforts and improve its access to state and local resources.

Malcolm Baldrige National Quality Award Program - P.L. 100-107, the Malcolm Baldrige National Quality Improvement Act of 1987, signed by President Reagan on August 20, 1987, established an annual U.S. National Quality Award. The purposes of the Award are to promote quality awareness, recognize quality achievements of U.S. companies, and to publicize successful quality strategies. The Secretary of Commerce and NIST administer the Award. Up to two Awards may be given each year in each of the following three categories: manufacturing companies or subsidiaries; service companies or subsidiaries; and small businesses. The first three Awards were announced on November 14, 1988, and included Globe Metallurgical, a small business headquartered in Beverly, Ohio, which produces specialty alloys and silicon metal.

Support of Local Economic Development Programs - NIST staff have been very active in the Montgomery County (Maryland) High Technology Council in attracting high-tech small businesses into the County and in making them aware of the Institute's research programs. NIST was instrumental in founding the Center for Advanced Research in Biotechnology (CARB), a shared research facility supported by the University of Maryland and the State, and located in the new Montgomery County Life Sciences Center.

In addition to the specific programs outlined above, the Institute conducts more than 100 major technical conferences and 600 workshops and seminars a year at which more than 15,000 persons from the States, universities, and private sector attend. Some 65% of these participants are from private industry, but statistics are not available as to what percentage come from small businesses.

Plan for Increased Activities

NIST considers that it is already doing an effective job of making small businesses aware of its research programs and activities. But NIST is also exploring new opportunities. For example, NIST will take a leadership role in working with State Technology Assistance Programs to network such activities at the State and local level with similar activities at the national level to provide pathways through which businesses, particularly small businesses, can access technical know-how. NIST is already working with the Federal Laboratory Consortium (FLC), the National Association of Management and Technical Assistance Centers (NAMTAC), the Association of Small Business Development Centers, the National Governors' Association (NGA), and other organizations to provide linkages with State technical assistance efforts. Such interaction with State and nationally focused programs will lead to greater outreach to small businesses by providing a nationally coordinated network through which

small businesses can access appropriate technical know-how at the local, State, or Federal level.

Develop Closer Links with State Technology Assistance Programs

Approach: Make contact with selected State technology assistance leaders, document program efforts, have senior NIST staff meet with State officials to discuss common technology transfer interests, promote technical level visits and cooperative interactions.

Progress in FY89: NIST has made contact with most State technology assistance officials in the context of its study of State Technology Extension Programs required under the Trade Act. Additionally, the Institute recently worked with officials from Pennsylvania, Ohio, and West Virginia to sponsor a joint conference and workshop for their technology extension agents to provide them training on how to access NIST and other Federal laboratories when seeking technical assistance for businesses within their regions. The Federal Laboratory Consortium also cooperated with NIST in the conference and workshop. Additional conferences and workshops will be planned as resources become available under the proposed State Technology Extension Program.

Inventory and Advertise Promising NIST Technology for Commercialization

Approach: Identify NIST research and development activities having commercial potential, give priority to manufacturing technologies, disseminate such information to State technology assistance officials, conduct targeted workshops for small businesses to make them aware of opportunities.

Progress in FY89: In cooperation with four other Federal laboratories in Montgomery County, the Montgomery County High Technology Council, and the Maryland Economic Development Organization, NIST sponsored a technology transfer workshop for approximately 100 high-tech small businesses in the Maryland and Virginia areas to introduce them to selected technologies within the five Federal laboratories. NIST is also working with the Commonwealth of Puerto Rico's newly established Center for Technology Transformation on a Memorandum of Understanding to transfer manufacturing and other technical know-how to small businesses in Puerto Rico. The Institute is also participating in Department of Commerce economic development initiatives involving Minnesota and Michigan.

Seek Cooperative Arrangements with Small Business Interest Organizations

Approach: Develop or expand cooperative arrangements with the Association of Small Business Development Centers, the National Association of Management and Technical Assistance Centers, and other organizations with small business members having a potential interest in NIST technologies or technology transfer programs. Working relationships will also be explored with organizations such as the Licensing Executive Society, the American Intellectual Property Law Association, and non-profit organizations such as the Intellectual Property Owners, Inc., who might provide useful insight on patent and licensing issues

of concern to technology-based small business. All such arrangements would be designed to enhance the awareness of NIST activities among small businesses throughout the United States.

Progress in FY89: The NIST Energy-Related Inventions Program has concluded an agreement with the Association of Small Business Development Centers to provide small businesses information about the inventions evaluation program and to encourage their participation in the program. A similar agreement is currently being discussed with the National Association of Management and Technical Assistance Centers.

Work with the Federal Laboratory Consortium to Optimize Small Business Access to Federally Developed Technology

Approach: In cooperation with other FLC members, develop innovative ways to inventory Federal technology, establish mechanisms for disseminating such information through State technology extension programs, and establish mechanisms for linking individual small businesses to Federal laboratories and experts within such laboratories.

Progress in FY89: NIST has had several meetings with the FLC leadership to discuss plans that are being developed to respond to initiatives assigned under the Trade Act, particularly as regards the establishment of the State Technology Extension Program. NIST has asked the FLC to cooperate in the development of the implementation plan for the State Extension Program and, in particular, to identify its role in the Program. The FLC has agreed and meetings are continuing.



BEST AVAILABLE COPY

# A STUDY OF STATE TECHNOLOGY EXTENSION SERVICES: AN INTERIM REPORT

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology

February 1989

BEST AVAILABLE COPY

# A STUDY OF STATE TECHNOLOGY EXTENSION SERVICES: AN INTERIM REPORT

U.S. DEPARTMENT OF COMMERCE
National Institute of Standards and Technology

February 1989

## EXECUTIVE SUMMARY

The National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards, is conducting a study of state technology extension services. This study was requested in the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418); it is designed to capture information on the various programs the states are using to promote technological innovation. Interest in the various state programs is based both on their magnitude (estimated expenditures of $550 million in 1988) and their breadth (43 states have one or more programs aimed at promoting technological innovation). In addition, many states benefit from federal technology transfer programs as well as private sources of funding.

The study is being carried out in cooperation with the National Governors' Association (NGA). NIST and NGA are working through the Governors' Offices, primarily their Science and Technology Advisors, to capture the study data.

To date, no study of state economic development - technological innovation activities has focused on identifying those programs which reach out to provide technological assistance to businesses at the local level, or on the degree to which such programs make use of federal programs and activities in carrying out their missions. When completed, this study will document these activities as well as identify potential sources of synergism between the states and federal technology transfer programs. In addition to satisfying a Congressional request, this study provides a unique opportunity to inventory the level of state-funded activities involved in technological innovation and assistance, and will provide the basis for establishing a Department of Commerce Clearinghouse on State Technology Initiatives, which is also required under the Act.

The purpose of this Interim Report is to document the progress which has been made since Public Law 100-418 was signed into law on August 23, 1988. The report is primarily concerned with providing background material on a variety of state programs which were instrumental in the design of the overall study. This material is covered in Chapters 2 and 3. Chapter 2 discusses results from several recent surveys concerned with incentives and programs designed to promote technological innovation. Chapter 3 documents the process through which the study population was identified. Information on the survey instrument is then given. The chapter concludes with a discussion of how the survey is being conducted and will be documented in a Final Report. Three appendices are also included. Appendix A is a list of organizations currently being surveyed. Appendices B and C are copies of the survey instrument.

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# 1. INTRODUCTION

## 1.1 BACKGROUND

The Omnibus Trade and Competitiveness Act (Public Law 100-418) was signed into law on August 23, 1988. The Act created the National Institute of Standards and Technology (NIST) from the National Bureau of Standards (NBS), the nation's central laboratory for developing and disseminating measurement standards and scientific data. In addition to the name change, NIST was assigned new responsibilities which augment and build on the technical expertise of NBS. NIST is the only federal laboratory with a specific mission to support U.S. industry. Basically, NIST is charged to "assist industry in the development of technology and procedures needed to improve quality, to modernize manufacturing processes, to ensure product reliability, manufacturability, functionality, and cost-effectiveness, and to facilitate the more rapid commercialization ... of products based on new scientific discoveries."

The Act authorizes the Secretary of Commerce to conduct a nationwide study of state technology extension services and, within 120 days of the Act's implementation, to report findings and recommendations to Congress on an appropriate federal role in encouraging such programs. The Act specifies that the study include the following items:

A. A thorough description of each state program, including its duration, annual budget, and the number and types of businesses it has aided;

B. A description of any anticipated expansion of each state program and its associated costs;

C. An evaluation of the success of the programs in transferring technology[1], modernizing manufacturing processes, and improving the productivity and profitability of businesses;

D. An assessment of the degree to which state programs make use of federal programs, including the Small Business Innovation Research program and the programs of the Federal Laboratory Consortium, the National Technical Information Service, the National Science Foundation, the Office of Productivity, Technology, and Innovation, and the Small Business Administration;

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[1]Technology transfer may be defined as the process by which technology, knowledge, or information developed in one organization, in one area or for one purpose is applied and utilized in another organization, in another area, or for another purpose.

E. A survey of what additional federal information and technical assistance the programs could utilize; and

F. An assessment of how the services could be more effective agents for the transfer of federal scientific and technical information, including the results and application of federal and federally-funded research.

The study is being carried out by NIST in cooperation with the National Governors' Association (NGA). NIST and NGA are working through the Governors' Offices, primarily their Science and Technology Advisers, to capture the study data.

Two separate questionnaires are being used to capture the study data. The first (see Appendix B) is of a summary nature and is designed for use by State Coordinators (e.g., a Governor's Science and Technology Advisor). The Second (see Appendix C) is designed for use by the individual Program Managers. Appendix A contains a list of the state-funded economic development/technical outreach programs which have been identified as the study population. The questions which appear in the survey instrument are directly related to the study requirements listed under Items A through F of Public Law 100-418. Table 1.1 summarizes the relationships between the requirements outlined in the Act and specific sections and/or questions in the survey instrument.

To date, no study of state economic development activities has focused on identifying those programs which reach out to provide technological assistance to businesses at the local level, or on the degree to which such programs make use of federal programs and activities in carrying out their missions. This study provides a unique opportunity to inventory the level of state activities involved in technological innovation and assistance, and will provide the basis for establishing a Department of Commerce (DoC) Clearinghouse on State Technology Initiatives, which is also required under the Act.

## 1.2 PURPOSE

The purpose of this Interim Report is three-fold. First, and foremost, it documents the substantial progress which has been made towards completing the survey of state technology extension services called for in the legislation. Second, it documents the steps which will be taken in order to complete the survey in a timely manner. Third, it describes our plans for making the data from the survey available to a variety of interested parties. This includes making copies of the survey data available through the clearinghouse and providing computer-readable copies (i.e., diskettes) of the survey data to all organizations which completed questionnaires.

Table 1.1 Cross References Between the Survey Instrument and the Requirements for the Survey from the Omnibus Trade and Competitiveness Act of 1988

| P.L. 100-418 Item | Section or Question of Survey Instrument (see Appendix C ) |
|---|---|
| A | Section I |
| B | Questions 17, 19, 23, 24, 28, 33, 34, 36, 42, 43, 49 |
| C | Question 19 and Sections III through IX |
| D | Section II, especially question 20 |
| E | Section II, especially question 22 |
| F | Section II, especially question 21 |

## 1.3 SCOPE AND APPROACH

The material presented in this Interim Report is limited to a survey of the literature on state science and technology initiatives. This approach was necessary because, as of this date, only about 100 of the more than 300 questionnaires mailed have been returned. Since the states have expressed a general willingness to provide the requested information and to a certain extent enthusiasm for the type of information the survey will provide, it seems most appropriate that any detailed discussions of individual state programs be postponed until all of the relevant data have been collected and analyzed. This does not prevent us from summarizing some of the recent work carried out by associations and individual states. By and large, these studies have compiled and classified data on state programs which were invaluable both in developing the survey population and in designing the questionnaire.

The approach taken in preparing the Interim Report is as follows:

Chapter 2 discusses results from several recent surveys concerned with incentives and programs designed to promote technology-oriented development.

Chapter 3 documents the process through which the survey population was identified. Information on the survey instrument is then given. The chapter concludes with a discussion of how the survey is being conducted and will be documented in a Final Report.

## 2. STATE INITIATIVES DESIGNED TO STIMULATE TECHNOLOGY-ORIENTED INVESTMENT AND DEVELOPMENT

### 2.1 HISTORICAL PERSPECTIVE

In the past 10 to 20 years, several regions of the U.S. have developed strong local economies based on fast-growing, technology-oriented industries. Encouraged by these successes, state and local governments, universities and private sector groups are launching initiatives to promote similar technology-oriented development in their regions. They are optimistic because technology-oriented industries are spreading beyond their original strongholds. While technology-oriented industries represent less than one quarter of the total U.S. employment, they play a major role in many local economies and could be a force in the revival of distressed regions and cities, especially in the Midwest.

The intense competition for technology-oriented development has generated literally hundreds of state and local initiatives. State and local organizations are beginning to take a number of actions to encourage technological innovation and economic activity that would not happen without government interaction. Generally speaking, the three common goals of these initiatives are: (1) job creation; (2) business development; and (3) economic diversification.

Virtually every state has some form of incentive to either attract firms to locate within its boundaries or to keep new or established firms from moving. A recent survey published by the National Association of State Development Agencies (NASDA) provides a perspective from which to select a small set of incentives directed at technology-oriented economic development[2]. The NASDA study breaks incentives into two broad catergoies: financial and nonfinancial. Both categories of incentives are summarized in Table 2.1. We begin with a discussion of the single nonfinancial incentive shown in Table 2.1, customized industrial training. Each of the financial incentives appearing in Table 2.1 will then be discussed.

Trained labor increasingly is being viewed as an essential element in development, growth, and redevelopment efforts. Private industry realizes that training can make a difference in reducing manpower costs, increasing productivity, and even making certain operations possible when they rely on particular manpower skills. Many states have already discovered the strong relation between developing labor resources and developing business. In their traditional role of industrial attraction, states found that a suitable labor force was essential, and that training programs were a big help in upgrading the work force. In fact, the mere existence of such a training program acts as a powerful incentive to business. Consequently, most states have developed training programs customized to particular industries or even to specific company needs. The emphasis has always been on training workers

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[2] Directory of Incentives for Business Investment and Development in the United States: A State-by-State Guide, Washington, DC: National Association of State Development Agencies, 2nd Edition, 1986.



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Table 2.1 Mechanisms Used by States to Stimulate Business Investment and Development

Type of incentive (column headings for Table 2.1):

1. Customized Industrial Training
2. Direct Loan Programs
3. Enterprise Zones
4. Grant Programs
5. Industrial Development Bond Guarantees
6. Tax Incentives
7. Umbrella Bonds

| State | Incentive Provided (* = yes) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Alabama | * | | | * | | | |
| Alaska | | | | | | * | * |
| Arizona | | | | | | | |
| Arkansas | * | | * | | | | |
| California | * | * | * | | * | * | |
| Colorado | * | | | | | * | |
| Connecticut | * | * | * | | | | * |
| Delaware | * | | * | | | * | |
| Florida | * | * | * | | | * | |
| Georgia | * | | * | | | | |
| Hawaii | * | * | | | | | |
| Idaho | * | | | | | | |
| Illinois | * | * | * | * | | | * |
| Indiana | * | * | * | * | | * | |
| Iowa | * | | | | | * | * |
| Kansas | * | | * | | | | |
| Kentucky | * | * | * | | | | * |
| Louisiana | * | * | * | | | * | |
| Maine | | | | | * | * | * |
| Maryland | * | * | * | * | * | | * |
| Massachusetts | * | | | | * | | |
| Michigan | * | * | * | * | | * | |
| Minnesota | | * | * | | | * | |
| Mississippi | * | * | * | * | | * | |
| Missouri | * | * | * | * | * | * | * |

Table 2.1 Mechanisms Used by States to Stimulate Business Investment and Development (Continued)

Type of incentive (column headings for Table 2.1):

1. Customized Industrial Training
2. Direct Loan Programs
3. Enterprise Zones
4. Grant Programs
5. Industrial Development Bond Guarantees
6. Tax Incentives
7. Umbrella Bonds

| State | Incentive Provided (* = yes) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Montana | * | * | | | | | * |
| Nebraska | * | | | | | | * |
| Nevada | * | * | * | | | * | |
| New Hampshire | | | | | | | |
| New Jersey | * | * | * | * | * | * | |
| New Mexico | * | | | | | | |
| New York | * | * | | | * | * | * |
| North Carolina | * | | | * | | * | |
| North Dakota | * | | | | * | * | |
| Ohio | * | * | * | * | | * | |
| Oklahoma | * | * | * | | | * | |
| Oregon | | * | | * | | * | * |
| Pennsylvania | * | * | * | * | | * | |
| Rhode Island | * | * | | * | * | * | |
| South Carolina | * | * | | | | * | * |
| South Dakota | * | | | | | | |
| Tennessee | * | | | | | | |
| Texas | * | * | | | | | |
| Utah | | | | | | * | |
| Vermont | * | * | | | | | |
| Virginia | * | | * | | | * | * |
| Washington | | | | | | * | |
| West Virginia | * | * | | | | * | |
| Wisconsin | * | | | * | | * | |
| Wyoming | | | | | | | * |

for real jobs, in real companies, which were likely to be available to them. The programs have been designed to reflect local economic realities and private corporate needs, with the latter a major factor. The private sector always plays a central role in the design and implementation of these training programs. More than 40 states have formal customized training programs.

Financial incentives are a major component of virtually all state programs. States depend on outreach activities and investment incentives to bring companies and investment into their jurisdictions. States provide a range of technical services such as demographic data on communities and the work force, as well as information on available sites and buildings. These services, along with the growing number of financial incentives, provide powerful follow-up to state advertising outreach efforts.

Direct financial incentives include direct state loans, grants, industrial development bonds (IDBs), and loan guarantees. States also provide various tax exemptions, deductions, and credits as incentives to businesses and investors.

One or more direct loan programs are reported in more than half the states. Many loan programs are established as revolving funds in order to make the most of limited capitalization. These are of special interest to small- and medium-sized businesses because maximum loan amounts are often less than $1 million. Most often a state provides less than 100 percent of the total project costs. In many instances, the state's loan is provided as part of an overall package that includes a commercial loan. State direct loans usually carry a below-market interest rate.

Enterprise zone programs could almost be classified as advanced tax incentive programs. The initial concept was to embody a basic premise of economic development: to leverage investment by reducing the cost of doing business. Enterprise zones carry with them the idea of targeting assistance to specified "distressed" areas within the state. Businesses locating or expanding in these designated areas are eligible for a variety of incentives, which vary by state. Currently nearly half the states have an enterprise zone program.

Grants are the most direct and heavily subsidized form of state assistance. Because of the high cost, nonretrievability, and legal constitutional constraints on such assistance, direct state grants to businesses are rare. States do, however, give grants to help underwrite various costs of economic development. Examples include grants to build or improve the physical infrastructure; grants to support R & D activities, support local economic development activities, and help subsidize and implement specific development projects.

The most common tool used for economic development financing is the industrial development bond (IDB) program. All 50 states allow for the issuance of such bonds; some actually issue the bonds at the state level. The interest on IDBs is federally tax exempt, and the lower rates that can be paid on such bonds are then passed on to the companies by the public issuer.

Most commonly, IDBs are used to subsidize the financing of land and site development or of other fixed assets.

Two of the more innovative uses of IDBs, industrial development bond guarantees and umbrella bond issues, are designed to make IDB financing available to small businesses. IDB guarantees are similar in principle to loan guarantees. The additional security provided by the guarantee improves the marketability of the bonds. Thus, these programs seek to improve the financing terms for sound companies with projects too small to attract investors. Currently, a little less than 20 percent of the states utilize IDB guarantees.

Umbrella bond issues are used by states to market several individual bond issues of $1 million or less in one package. This reduces the credit risk to the bond purchasers and lowers the costs of bond financing to the small businesses. Under most umbrella or pooled IDB programs, eligible loans are bundled as a package and bonds are sold when a certain minimum limit is reached. In general, umbrella bond programs provide financing for projects too small to qualify for the normal revenue bond program. With these programs, borrowers pay below-market interest rates for long-term loans. The pooled risk and economies of scale in costs permit the companies and private lenders to participate in deals that might otherwise be too risky or not sufficiently profitable. Roughly one third of the states have some form of pooling program, and the number is expected to grow.

Tax incentives can promote economic development in a variey of ways. These include reduction of the overall level of taxation, both personal and business taxes, revision of the tax structure, and use of tax credits to encourage particular types of investments. A recent survey by the National Governors' Association[3] indicated that 15 states have recently enacted tax cuts to stimulate economic activity. Twelve states reported decreases in business taxes, and five reported decreases in personal income tax rates. Two states repealed unitary tax measures and three revised their unitary tax adopting the water's edge concept. The unitary tax method allows states to tax corporations based on the ratio of their state profits to their worldwide profits. Under a water's edge system, companies are taxed on earnings based on the ratio of their in-state profits to their profits within the United States. Profits earned in foreign countries are excluded from the calculation.

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[3]Marianne K. Clarke, Revitalizing State Economies: A Review of State Economic Development Policies and Programs, Washington, DC: National Governors' Association, 1986.

## 2.2 ORGANIZATION OF STATE EFFORTS

Currently, 43 states have at least one program that specifically encourages technological innovation[4]. Programs range from business assistance to comprehensive, multi-million dollar programs. Some states invest in only one type of technology program, while others approach technological development by investing in a number of areas simultaneously.

Table 2.2 summarizes information on the 36 states which have boards, commissions, authorities, or offices that oversee or coordinate state technology initiatives. The most common type of structure is a public/private partnership comprised of representatives from private firms, academia, and state government. Technology offices may operate as independent public agencies or private nonprofit corporations. States without a technology office may have a science and technology policy advisor. The duties and responsibilities of technology offices range from the administration of multi-million dollar technology centers to providing information dissemination and advisory services.

Over $550 million was allocated for state science and technology initiatives for the 1988 fiscal year. Information on six general classes of state technology programs is provided in the Table 2.3. A seventh class, Other, is also included in the table to indicate the importance of highly-focused programs which have a local or regional flavor. The following is a brief description of the six classes of state technology programs summarized in Table 2.3:

**Business Assistance:** Business assistance focuses on providing general business management information such as personnel, accounting and legal advice.

**Incubators:** Incubator facilities provide office and lab space for start-up companies at below-market rates. Shared support services such as clerical, reception and data processing are often made available.

**Research Parks:** Research parks are planned groupings of technology companies that encourage university/private relationships.

**Seed Capital:** Money is provided for projects that are at an early stage of development or that offer job creation potential but may not have the return on investment expected by commercial venture capitalists. Includes research grant and product development programs.

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[4]The material presented in this section is excerpted from: State Technology Programs in the United States, St. Paul, MN: Office of Science and Technology, Minnesota Department of Trade and Economic Development, July 1988.

Table 2.2 State Offices for Promoting Initiatives in Science and Technology

| State | Office |
|---|---|
| Alabama | Alabama Department of Economic and Community Affairs |
| Alaska | Science and Engineering Advisory Commission |
| Arkansas | Arkansas Science and Technology Authority |
| Colorado | Colorado Advanced Technology Institute |
| Connecticut | Governor's Technology Advisory Board |
| Delaware | High Technology Task Force |
| Florida | Florida High Technology and Industry Council |
| Georgia | Advanced Technology Development Center |
| Hawaii | High Technology Development Corporation |
| Illinois | Governor's Commission on Science and Technology |
| Indiana | Corporation for Science and Technology |
| Iowa | Iowa High Technology Council |
| Kansas | Kansas Technology Enterprise Corporation |
| Kentucky | Office of Business and Technology |
| Maine | Maine Science and Technology Board |
| Maryland | Science Advisory Council |
| Massachusetts | Massachusetts Office of Science and Technology |
| Michigan | Michigan High Technology Task Force |
| Minnesota | Office of Science and Technology |
| Missouri | Missouri Corporation for Science and Technology |
| Montana | Montana Science and Technology Alliance |
| Nebraska | Nebraska Research and Development Authority |
| New Jersey | New Jersey Commission on Science and Technology |
| New Mexico | New Mexico Science and Technology Commission |
| New York | New York Science and Technology Foundation |
| North Carolina | North Carolina Board of Science and Technology |
| Ohio | Thomas Edison Program |
| Oklahoma | Oklahoma Center for the Advancement of Science and Technology |
| Oregon | Oregon Resource and Technology Development Corporation |
| Pennsylvania | Ben Franklin Partnership Program |
| Rhode Island | Rhode Island Partnership for Science and Technology |
| South Carolina | South Carolina Research Authority |
| Tennessee | Tennessee Technology Foundation |
| Virginia | Center for Innovative Technology |
| Washington | Washington High Technology Coordination Board |
| Wyoming | Wyoming Science, Technology, and Energy Authority |

**Technology Assistance:** Technology assistance focuses on providing specialized services such as technical information, invention evaluation, technical counseling and patent infromation. Technology assistance includes both information exchange and active out-reach programs to provide access to newly-created technologies and to promote innovative applications of established technologies.

**Technology/Research Centers:** These centers generally concentrate their studies in a particular field which is usually based on the strengths of the university and/or the major industries in the State.

During fiscal year 1988, individual state expenditures for science and technology programs vary from no allocation to over $76 million. In general, those states that have invested most intensely in technology programs are the traditional manufacturing states of the Northeast and Midwest. Rural and Western states tend to provide the fewest programs and the least money. Reference to Table 2.3 reveals that 30 states offered business assistance, 18 had incubators, 11 had research parks, 31 provided seed capital, 40 offered technology assistance, 30 funded technology/research centers and 37 operated one or more special-purpose programs.

Most of the financial resources for these programs come from state general funds. Other sources include bond issues, state lottery funds, pari-mutuel gambling receipts, and state employee pension funds. Iowa and Oregon use lottery funds in addition to state general funds. Kansas allocates both state general funds and gaming funds. Alabama's general funds are complemented by the State Trust Fund Income. South Dakota's Future Funds are residuals from its unemployment compensation reserve.

## 2.3 TECHNOLOGIES TARGETED[5]

Many state programs target one or more particular technologies that states hope to develop. In fact, states have targeted over 64 different technologies. These include technologies as diverse as biomedical, energy, food processing, lasers, robotics, superconductivity, and welding.

Grouping similar technologies into categories, Table 2.4 provides a convenient state-by-state summary. As might be expected, biotechnology and information technologies have been targeted by many of the states. Reference

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[5]The material presented in this section is based on information from: Robert D. Atkinson, State Programs for Technology Development, Washington, DC: National Association of State Development Agencies, April 1988; and Paul B. Phelps, Centers of Excellence: A Catalogue, St. Paul, MN: Office of Science and Technology, Minnesota Department of Energy and Economic Development, January 1988.

Table 2.3 Selected Science and Technology Programs by State

Type of program (column headings for Table 2.3):

1. Business Assistance
2. Incubators
3. Research Parks
4. Seed Capital
5. Technology Assistance
6. Technology/Research Centers
7. Other

| State | Type of Program (* = provided) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Alabama | * | * | | * | * | | * |
| Alaska | * | | | | | | * |
| Arizona | * | | * | | | * | |
| Arkansas | * | * | | * | * | | * |
| California | | | | * | | | |
| Colorado | | | | | * | * | * |
| Connecticut | | * | * | * | * | | * |
| Delaware | * | | * | | * | * | * |
| Florida | | | | * | * | | * |
| Georgia | * | * | | | * | * | * |
| Hawaii | * | * | * | * | * | * | * |
| Idaho | * | | | | | * | |
| Illinois | | * | * | * | * | | * |
| Indiana | * | | | * | * | | * |
| Iowa | * | * | * | * | * | * | * |
| Kansas | * | | | * | * | * | * |
| Kentucky | * | * | * | * | * | * | * |
| Louisiana | | | | | | | |
| Maine | | | | * | * | | * |
| Maryland | * | * | | | * | * | * |
| Massachusetts | | | | | * | * | * |
| Michigan | * | | | * | * | * | * |
| Minnesota | * | | * | * | * | * | * |
| Mississippi | * | | | | * | | |
| Missouri | | * | * | | * | * | * |

Table 2.3 Selected Science and Technology Programs by State (Continued)

Type of program (column headings for Table 2.3):

1. Business Assistance
2. Incubators
3. Research Parks
4. Seed Capital
5. Technology Assistance
6. Technology/Research Centers
7. Other

| State | Type of Program (* = provided) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Montana | * | | | * | * | | * |
| Nebraska | * | | | * | * | * | * |
| Nevada | | | | | | | |
| New Hampshire | * | * | | | | | |
| New Jersey | * | * | | * | * | * | * |
| New Mexico | | | | * | * | * | * |
| New York | * | | | * | * | * | * |
| North Carolina | * | * | | * | * | * | * |
| North Dakota | * | | | | * | * | * |
| Ohio | | * | | * | * | * | * |
| Oklahoma | | | | * | * | * | * |
| Oregon | * | | | * | * | | * |
| Pennsylvania | * | * | | * | * | * | * |
| Rhode Island | | | | * | * | * | * |
| South Carolina | * | | * | | | | * |
| South Dakota | | | | * | | | |
| Tennessee | * | | * | * | * | * | * |
| Texas | * | | | * | * | | |
| Utah | | | | | * | * | |
| Vermont | | * | | * | * | | |
| Virginia | * | * | | * | * | * | * |
| Washington | * | * | | | * | * | * |
| West Virginia | | | | | * | * | |
| Wisconsin | | | | * | * | * | |
| Wyoming | | | | | | | * |

to the table shows that 23 states targeted biotechnology and the life sciences and 23 targeted information technologies. Similarly, materials sciences were targeted by 22 of the states.

Many states target technologies which hold promise for being spun off and enhancing the state's existing economic base. For example, while Michigan targets such emerging technologies as biotechnology and materials sciences, it also is placing a major emphasis on developing advanced manufacturing process technologies, including robotics and flexible manufacturing systems. In fact, at least 13 states are targeting manufacturing technologies.

Other states have targeted technologies for development which, while not making up a large part of their current industrial structure, are hoped to contribute to new forms of development in the future. For example, the Microelectronics Center of North Carolina is a major research effort designed to both attract microelectronics firms to the state and to support the microelectronic firms currently in the state. Similarly, Colorado is targeting, among other technologies, computers and artificial intelligence.

Research and development of semiconductor and related technologies figure prominently in many state programs. These activities often involve basic and applied research in materials sciences in conjunction with with research on manufacturing processes and information technologies. At least 20 states have one or more programs focused on semiconductor and related technologies. For example, the Microelectronics Research Center located at the Georgia Institute of Technology is focusing its research effort on compound semiconductor materials, microwave, millimeter wave, and integrated optics. Minnesota's Microelectronics and Information Sciences Center seeks to enhance university/industry linkages. This is accomplished by conducting research, with industrial participation, in the areas of high-performance integrated circuits, intelligent systems, artificially structured materials for microelectronics, compound semiconductor materials, and high-speed devices.

State programs also affect siting decisions by industrial consortia. For example, state support and the resources of the University of Texas helped persuade the Microelectronics and Computer Technology Corporation (MCC), a consortium of 20 major corporations, and the Semiconductor Technology Corporation (SEMATEC) to locate in Austin.

Table 2.4 Technologies Targeted by State

Type of technology targeted (column headings for Table 2.4):

1. Aerospace
2. Biotechnology and Life Sciences
3. Earth Sciences
4. Information Technologies
5. Manufacturing Technologies
6. Materials Sciences
7. Other

| State | Technology Targeted (* = yes) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Alabama | | | | | | | |
| Alaska | | | | | | | |
| Arizona | | | | * | | | * |
| Arkansas | | * | | | | | |
| California | | | | * | | | |
| Colorado | * | | | * | | * | |
| Connecticut | | | | | | | |
| Delaware | | | | | | | |
| Florida | | * | | * | | * | |
| Georgia | | * | | * | * | * | * |
| Hawaii | | * | * | * | | | * |
| Idaho | | | | | | | |
| Illinois | | * | | * | * | * | * |
| Indiana | | | | | | | |
| Iowa | | | | | | | |
| Kansas | * | * | | * | * | * | * |
| Kentucky | | | | | | * | |
| Louisiana | | | | | | | |
| Maine | | | | | | | |
| Maryland | | * | | | | | * |
| Massachusetts | | * | * | | * | * | * |
| Michigan | | * | | * | * | * | * |
| Minnesota | | * | * | * | | * | * |
| Mississippi | * | * | | * | | * | |
| Missouri | | | | | * | | * |

Table 2.4 Technologies Targeted by State (Continued)

Type of technology targeted (column headings for Table 2.4):

1. Aerospace
2. Biotechnology and Life Sciences
3. Earth Sciences
4. Information Technologies
5. Manufacturing Technologies
6. Materials Sciences
7. Other

| State | Technology Targeted (* = yes) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Montana | | | | | | | |
| Nebraska | | * | | | | | * |
| Nevada | | | | | | | |
| New Hampshire | | | | | | | |
| New Jersey | | * | | * | * | * | * |
| New Mexico | | * | | * | | * | * |
| New York | | * | | * | | * | * |
| North Carolina | | * | | * | | * | |
| North Dakota | | | | | | | |
| Ohio | | * | | * | * | * | * |
| Oklahoma | | | | | | | |
| Oregon | | | | | | | |
| Pennsylvania | * | * | | * | * | * | |
| Rhode Island | | | | | | | |
| South Carolina | | | | | | | |
| South Dakota | | | | | | | |
| Tennessee | * | * | * | * | * | * | * |
| Texas | | | | * | | * | |
| Utah | * | * | * | * | * | * | |
| Vermont | | | | | | | |
| Virginia | | * | | * | * | * | * |
| Washington | | * | | * | | * | |
| West Virginia | | | | | | | * |
| Wisconsin | | * | | * | * | * | |
| Wyoming | | | | | | | |

## 3. SURVEY-RELATED ISSUES

### 3.1 DEVELOPMENT OF SURVEY POPULATION

To date, no study of state economic development activities has focused on identifying those programs which reach out to provide technological assistance to businesses at the local level, or on the degree to which such programs make use of federal programs and activities in carrying out their missions. To develop the list of programs which constitute the survey population, NIST has completed exhaustive reviews of past studies covering state-supported economic development programs, and conducted numerous site visits and interviews with state economic development officials. Through this approach, the state-funded economic development/technical outreach programs listed in Appendix A were identified as the survey population.

The following is a list of the studies reviewed.

a. State Technology Programs in the United States, St. Paul, MN: Office of Science and Technology, Minnesota Department of Trade and Economic Development, 1988.

b. Marianne Clarke, State-Supported SBIR Programs and Related State Technology Programs, Washington, DC: National Governors' Association, 1988.

c. Charles Watkins, Programs for Innovative Technology Research in State Strategies for Economic Development, Washington, DC: National Governors' Association, 1986.

d. National Resource Guide of Member Institutions, Washington, DC: National Association of Management and Technical Assistance Centers, 1987.

e. Directory of Federal and State Business Assistance: A Guide for New and Growing Companies, Washington, DC: National Technical Information Service, 1986.

f. The States and Small Business: Programs and Activities, Washington, DC: Small Business Administration, 1986.

g. Robert Atkinson, State Programs for Technology Development: A Summary and State-by-State Listing, Washington, DC: National Association of State Development Agencies, 1988.

h. 1986 State Development Agency Expenditure and Salary Survey, Washington, DC: National Association of State Development Agencies, 1987.

i. Paul B. Phelps, Centers of Excellence: A Catalogue, St. Paul, MN: Office of Science and Technology, Minnesota Department of Trade and Economic Development, 1988.

j. State Government Strategies for Self-Assessment of Science and Technology Programs for Economic Development, Washington, DC: National Academy Press, 1988.

k. Key State and Education Contacts Relating to Science, Technology and Economic Development, Lexington, KY: The Council of State Governments, 1986.

l. State Administrative Officials Classified by Function 1987-88, Lexington, KY: The Council of State Governments, 1987

Such studies have been useful in helping to identify the population of state programs that should be included in the proposed study, but do not provide sufficient information on which to base the Secretary's required report. Similarly, NIST has not identified current studies in progress or in planning stages that request the same kind of information.

## 3.2 QUESTIONNAIRE DESIGN

In order to conduct the survey, it was necessary to develop two separate questionnaires. The first (see Appendix B) is of a summary nature and is designed for use by State Coordinators. The second (see Appendix C) is designed for use by the individual Program Managers. Each of the respondents has been asked to complete a questionnaire.

The survey has been designed to capture information on what each state is doing to promote technological innovation and job creation. The two questionnaires differ in their focus. The State Coordinator's version establishes a set of control totals against which the individual programs can be measured. The Program Manager's version is fairly detailed and is divided into two parts: (1) background information; and (2) program orientation. Background information (Part 1) relates to: the size and objectives of the respondent's organization; funding levels; number and types of businesses assisted; percentage of resources allocated to six broad-based economic development functions; and, the respondent's knowledge of and relationships with key Federal programs. Every respondent will be asked to complete all of Part 1. Program orientation (Part 2) subdivides into six sections, depending upon the orientation of the respondent's organization (e.g., business assistance versus technology assistance). Respondents would only complete those sections of Part 2 that relate to their program.

The questions which appear in the survey instrument are directly related to the study requirements listed under Items (A) through (F) of the Omnibus Trade and Competitiveness Act of 1988 (see Section 1.1 above). Since the Program Manager's version of the survey instrument is divided into several sections, certain sections may focus on more than one requirement and vice versa. Table 3.1 summarizes the relationships between the requirements outlined in the Act and specific sections and/or questions in the survey instrument.

Table 3.1 Cross References Between the Program Manager's Version of the Questionnaire and the Requirements for the Survey from the Omnibus Trade and Competitiveness Act of 1988

| P.L. 100-418 Item | Section or Question of Survey Instrument (Program Manager's Version) |
|---|---|
| A | Section I |
| B | Questions 17, 19, 23, 24, 28, 33, 34, 36, 42, 43, 49 |
| C | Question 19 and Sections III through IX |
| D | Section II, especially question 20 |
| E | Section II, especially question 22 |
| F | Section II, especially question 21 |

The survey instrument (see Appendices B and C) has undergone review by selected experts from within state economic development programs, as well as by survey specialists within the National Science Foundation and the National Governors' Association. The purpose of this review was to ensure that the survey instrument was relevant, complete, and understandable to practioners in the economic development field. Among those subject-area specialists who reviewed the survey instrument, are the following:

Dr. H. Leroy Marlow, Director, Pennsylvania Technical Assistance Program, Pennsylvania State University, University Park, PA.

Dr. Gene Calvert, Director, Technology Transfer, Center for Innovative Technology, Herndon, VA.

Ms. Beverly Jones, Executive Director, Governor's Office of Science and Technology, St. Paul, MN.

Mrs. Margaret R. Grucza, Director, Government Studies, National Science Foundation, Washington, DC.

Mrs. Marianne K. Clarke, Center for Policy Research, National Governors' Association, Washington, DC.

Dr. Walter H. Plosila, President, Montgomery County High Technology Council, Inc., Rockville, MD.

Ms. Donna Grinstead, Federal Coordinator, Ohio's Thomas Edison Program, Columbus, OH.

Mr. Jeff Schick, Ohio Technology Transfer Organization (OTTO), Columbus, OH.

Mr. J. Ronald Thornton, Director, NASA Southern Technology Applications Center, Alachua, FL.

Shortly after the Omnibus Trade and Competitiveness Act of 1988 was signed into law, a formal request for OMB review of the survey instrument was made. On September 7, 1988, the request for "emergency" clearance was received by the Departmental Clearance Officer, Office of Management and Organization at OMB.

The justification for the clearance request and the entire Program Manager's version of the questionnaire were published in the Federal Register[6] on September 15, 1988. Approval for the questionnaire was granted on September 28, 1988 (OMB Control Number 0693-0007).

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[6] Federal Register, Vol. 53, No. 179, Thursday, September 15, 1988, pp. 35873-82.

### 3.3 COOPERATION WITH THE NATIONAL GOVERNORS' ASSOCIATION[7]

The study is being conducted jointly by NIST and the National Governors' Association (NGA). This approach was taken because NGA has played a key role in promoting state initiatives to support technological innovation. NIST is working closely with NGA and, through it, with its established network of contacts in the Governors' Offices in assuring a maximum amount of cooperation from respondents and to prevent overlap or possible duplication of effort.

In 1986, NGA's Committee on Economic Development and Technological Innovation appointed Richard Celeste, Governor of Ohio, as the Lead Governor for Science and Technology. Under his direction, a Working Group on State Initiatives in Applied Research has been organized. The members of the Working Group include Governors' Science Advisors and directors of state technology development programs.

To obtain the data requested in the Omnibus Trade and Competitiveness Act of 1988, NGA is administering, on behalf of NIST, a survey of current state technology extension services. The survey instrument, described earlier, was designed by NIST. NGA and NIST are working through the Governors' Offices, specifically the members of the Working Group on State Initiatives in Applied Research, to capture the study data. Appendix A contains a list the state-funded economic development/technical outreach programs which have been identified as the study population.

In early November, the survey instrument was sent to the Governors via a transmittal letter jointly signed by the Secretary of Commerce and Governor Gerald Baliles of Virginia, the Chairman of the NGA. Accompanying the transmittal letter and survey instrument was a list of organizations involved in economic development and/or technical outreach programs, with a request that the Governor's Office coordinate the State's response. NIST and NGA are working with each State Coordinator to confirm the list of respondent organizations within the state and to have respondents complete the survey. All survey data is to be returned to NGA for machine processing.

### 3.4 CURRENT AND FUTURE ACTIVITIES

The questionnaires mailed out in early November are beginning to be returned to NGA for processing. The incoming questionnaires are of two basic types. Those programs which are state funded are being returned through the State Coordinator; these questionnaires are coming in on a state-by-state basis.

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[7]On September 15, 1988, NIST issued a grant to the National Governors' Association to "conduct a nationwide study of state technology extension services." The grant includes the following research activities: (1) identify state programs and key personnel; (2) collect information on state programs; (3) compile information on state programs; (4) analyze information on state programs; (5) organize a roundtable to review preliminary findings; and (6) document findings. All research is to be conducted in accordance with NGA's proposal dated August 23, 1988.

Those programs which receive a portion of their support from the federal government are being returned on an individual program basis. This is because each was mailed directly a Program Manager's version of the questionnaire. For example, all Small Business Development Centers, University Centers, Trade Adjustment Assistance Centers, and NASA Industrial Applications Centers, receive a portion of their funds from the Small Business Administration, the Economic Development Administration, the International Trade Administration, and NASA, respectively. Each of these programs was surveyed directly.

Future activities include the following: (1) collection, compilation and analysis of the survey data; (2) conduct a roundtable to review preliminary findings; and (3) prepare and disseminate study findings.

As the questionnaires are received at NGA, the data will be collated, reviewed and entered into a database. Once the survey data has been entered into the database, it will be verified for accuracy and completeness. Upon completion of the database, analysts from NIST and NGA will develop a variety of summary statistics and prepare a draft report. These statistics should serve to highlight differences and similarities between programs due to their geographical location, size and orientation, and their use of federal programs.

Several members of the Working Group on State Initiatives in Applied Research, and other individuals with expertise on the topic of technology extension services, will be asked to review the draft report and participate in a roundtable discussion of the preliminary findings. The purpose of the roundtable will be to review our progress, present results, and provide an opportunity for comments and suggestions for alternative methods of analysis.

NGA will assist DoC in preparing recommendations to Congress on an appropriate federal role in encouraging technology extension services. NGA will arrange for selected members of the Working Group on State Initiatives in Applied Research to reveiw these recommendations prior to their submission to Congress. NGA and NIST will prepare jointly a Final Report documenting the methodology and results of the study. The Final Report will include descriptions of state programs as well as summary data from the survey. NIST will make the Final Report available to the Department of Commerce Clearinghouse for dissemination to interested parties. NGA will provide an alternative point of access for the survey data to ensure that it is made available to a wide range of individuals interested in technological innovation.

NIST and NGA plan to make the data collected in the survey available to the state technical extension services which participated in the survey and to other interested parties. Currently, we are exploring the use of DBASE III+ and other commercially available software packages as a transfer mechanism. The advantage of this approach is that it would enable users to browse through the database, identify similar programs in other parts of the country, and generate customized mailing lists and program descriptions.

## 4. CONCLUDING REMARKS

This Interim Report has focused on documenting NIST's progress towards completing the study of state technology extension services called for in the Omnibus Trade and Competitiveness Act of 1988. Emphasis has been placed on the role of previous studies in shaping both the survey population and the information requested in the survey questionnaire. The report also focused on NIST's cooperative effort with NGA and how this effort will promote a more comprehensive compilation of data on state-supported economic development/ technical outreach programs.

# APPENDIX A

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# APPENDIX B

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# A STUDY OF CURRENT STATE TECHNOLOGY EXTENSION SERVICES

## SUMMARY QUESTIONNAIRE

## TO BE COMPLETED BY STATE COORDINATORS

Congress and the Administration have called upon the National Institute of Standards and Technology, formerly the National Bureau of Standards, to carry out a program of technology development and transfer in collaboration with industry, universities, other Federal agencies, and with State and local governments. Among the National Institute of Standards and Technology's new responsibilities outlined in the Technology Competitiveness Act portion of the Trade Bill, is a Study of Current State Technology Extension Services. The Study is being undertaken jointly with the National Governors' Association (NGA) with advice and guidance from the NGA Working Group on State Initiatives in Applied Research.

The purpose of the Study is to provide an understanding of what each State is doing to promote technological innovation and job creation. This information will be useful for Congress in identifying a Federal role which is supportive of State efforts and will be of use to Governors in assessing the effectiveness of their technology extension efforts.

In order to cover a wide array of State programs that may be administered by a number of different agencies or offices, we are asking that the members of the NGA Working Group serve as State coordinators. The State coordinator will be responsible for: (1) completing this Summary Questionnaire, if applicable; and (2) either completing the Program Manager's Questionnaire or distributing it to the appropriate State offices for completion. The Program Manager's Questionnaire requests information on the following types of programs: (1) Business Assistance; (2) Incubators; (3) Research Parks; (4) Seed Capital; (5) Technology Assistance; and (6) Technology/Research Centers. If the State operates several programs within any of these categories, please complete a survey form for each program.

Attached is a list of programs which we have identified in your State for inclusion in the study. Please add any programs that have been omitted. Please note that Small Business Development Centers and EDA-supported University Centers will receive questionnaires directly and need not be included in your response.

We would like to thank you in advance for your cooperation and support. We know that the completion of the questionnaire will require time and effort on your part but we believe the final product will be useful to you and your colleagues in other States. If you have any questions, please call Marianne Clarke at (202) 624-5380.

**PLEASE RETURN BY NOVEMBER 30, 1988**

This questionnaire was approved by the Office of Management and Budget (OMB) on September 28, 1988, OMB Control Number 0693-0007.

This Summary Questionnaire should be completed only by those States with a single office responsible for science and technology programs. If such an office does not exit, please complete the Program Manager's Version of the questionnaire.

## SECTION I: GENERAL INFORMATION

1. Organization Name: _____

2. Administering Agency: _____

3. Address: a) _____

   b) _____

   c) _____

4. City: _____ 5. State: _____

6. Zip Code _____ 7. Date Established: _____

8. Director: _____

9. Title: _____

10. Telephone: _____

11. Principal Contact: _____

12. Title: _____

13. Telephone: _____

14. Telecopier: _____

15. Number of staff (full-time equivalent) employed (as of June 30, 1988):

    a) Professional (Technical): _____

    b) Professional (Business): _____

    c) Support Staff: _____

16. Organizational Objectives (50 words or less):

17. **Financial Data:** Estimate the total funds (including overhead and any other operating costs) received or anticipated (in thousands of $) by your organization by fiscal year from each of the sources listed below. Indicate when your fiscal year begins (_____).

| Source of Funds | Funds (thousands of $) | | | |
|---|---|---|---|---|
| | 1986 | 1987 | 1988 | 1989(est) |
| a) Federal Government | | | | |
| b) State Government | | | | |
| c) Local Government | | | | |
| d) University | | | | |
| e) Industry | | | | |
| f) All Other | | | | |
| TOTAL | | | | |

**Please use the following definitions in answering question 18.**

**Business Assistance:** Business assistance focuses on providing general business management information such as personnel, accounting and legal advice.

**Incubators:** Incubator facilities provide office and lab space for start-up companies at below-market rates. Shared support services such as clerical, reception and data processing are often made available.

**Research Parks:** Research parks are planned groupings of technology companies that encourage university/private relationships.

**Seed Capital:** Money is provided for projects that are at an early stage of development or that offer job creation potential but may not have the return on investment expected by commercial venture capitalists. Includes research grant and product development programs.

**Technology Assistance:** Technology assistance focuses on providing specialized services such as technical information, invention evaluation, technical counseling and patent information. Technology assistance includes both information exchange and active out-reach programs to provide access to newly-created technologies and to promote innovative applications of established technologies.

**Technology/Research Centers:** These centers generally concentrate their studies in a particular field which is usually based on the strengths of the university and/or the major industries in the State.

18. **Program Orientation:** List the programs supported by your office and the date they were established.

| Functional Area | Program Name and Date Established |
|---|---|
| a) Business Assistance | |
| | |
| b) Incubators | |
| | |
| c) Research Parks | |
| | |
| d) Seed Capital | |
| | |
| e) Technology Assistance | |
| | |
| f) Technology/Research Centers | |
| | |

19. **Support Services:** Check the box in Column 1 if your office provided that service during 1985, 1986 or 1987. Check the box in Column 2 if your ogranization is currently providing that service. Check the box in Column 3 if your organization is either providing that service at an increased level or is planning an expansion in 1989.

| Type of Service | Column 1 Provided 85, 86, 87 | Column 2 Provided 88 | Column 3 Expanded 88 or 89 |
|---|---|---|---|
| a) Bond Issues for Technology-Based Businesses | ☐ | ☐ | ☐ |
| b) Business and/or Technology Assistance to Small and Medium-Sized Businesses | ☐ | ☐ | ☐ |
| c) Export Assistance for Technology-Based Businesses | ☐ | ☐ | ☐ |
| d) Industry-University (Research and/or Personnel Exchange) | ☐ | ☐ | ☐ |
| e) Joint Venture/Partnership Counseling | ☐ | ☐ | ☐ |
| f) Marketing Programs for Technology-Based Businesses | ☐ | ☐ | ☐ |
| g) Matching Grants | ☐ | ☐ | ☐ |
| h) Networking and Referrals | ☐ | ☐ | ☐ |
| i) Patenting and Licensing | ☐ | ☐ | ☐ |



98-198 O - 89 - 30

## SECTION II: RELATIONSHIPS WITH FEDERALLY-SPONSORED PROGRAMS

20. If your organization has used or been associated with a specific program, provide an assessment of how well that program complements your organization's objectives.

| Program Name | Have Used Program Y=Yes N=No | If Yes, Frequency of Use 1=Frequent 2=Sometimes 3=Seldom | If Yes, Program Assess. 1=Good 2=Fair 3=Poor |
|---|---|---|---|
| a) Center for Utilization of Federal Technology (Commerce/NTIS) | ☐ | ____ | ____ |
| b) Commercial Use of Space Program (NASA) | ☐ | ____ | ____ |
| c) Community Development Block Grants (HUD) | ☐ | ____ | ____ |
| d) Computer and Information Science and Engineering (NSF) | ☐ | ____ | ____ |
| e) Cooperative Extension Service (Agriculture) | ☐ | ____ | ____ |
| f) Energy Extension Service (Energy) | ☐ | ____ | ____ |
| g) Energy-Related Inventions (Energy and Commerce/NBS) | ☐ | ____ | ____ |
| h) Federal Laboratory Consortium (All) | ☐ | ____ | ____ |
| i) Industry/University Cooperative Research Centers (NSF) | ☐ | ____ | ____ |

20. (Continued)

| Program Name | Have Used Program Y=Yes N=No | If Yes, Frequency of Use 1=Frequent 2=Sometimes 3=Seldom | If Yes, Program Assess. 1=Good 2=Fair 3=Poor |
|---|---|---|---|
| j) Job Training Partnership Act (Labor) | ☐ | ____ | ____ |
| k) Measurement and Engineering Research Grants (Commerce/NBS) | ☐ | ____ | ____ |
| l) National Appropriate Technology Assistance Service (Energy) | ☐ | ____ | ____ |
| m) Office of Productivity, Technology and Innovation (Commerce) | ☐ | ____ | ____ |
| n) Office of Small and Disadvantaged Business Utilization (All) | ☐ | ____ | ____ |
| o) Patent and Trademark Office (Commerce) | ☐ | ____ | ____ |
| p) Program for Mathematics, Science, Computer Learning and Critical Foreign Languages (Education) | ☐ | ____ | ____ |
| q) Scientific, Technological and International Affairs (NSF) | ☐ | ____ | ____ |
| r) SCORE/ACE (SBA) | ☐ | ____ | ____ |
| s) Small Business Development Center Program (SBA) | ☐ | ____ | ____ |
| t) Small Business Innovation Research Program (All) | ☐ | ____ | ____ |

20. (Continued)

| Program Name | Have Used Program Y=Yes N=No | If Yes, Frequency of Use 1=Frequent 2=Sometimes 3=Seldom | If Yes, Program Assess. 1=Good 2=Fair 3=Poor |
|---|---|---|---|
| u) Small Business Investment Companies (SBA) | ☐ | ___ | ___ |
| v) Technology Utilization Program (NASA) | ☐ | ___ | ___ |
| w) Trade Adjustment Assistance Centers Program (Commerce/ITA) | ☐ | ___ | ___ |
| x) Trade Adjustment Assistance Workers (Labor) | ☐ | ___ | ___ |
| y) University Centers Program (Commerce/EDA) | ☐ | ___ | ___ |
| Other Federal Programs (Please List) | | | |
| aa)_____ _____ | ☐ | ___ | ___ |
| bb)_____ _____ | ☐ | ___ | ___ |
| cc)_____ _____ | ☐ | ___ | ___ |

21. Below is a list of strategies through which your organization does or could facilitate the transfer of Federal scientific and technical information, including the results and application of Federal and Federally-funded research/technology. Indicate the importance of each strategy by showing how you would allocate $100 of program funds among them.

| Strategies | How would you allocate $100? |
|---|---|
| a) Cooperate actively with Federal agencies in their technology transfer programs | _____ |
| b) Cosponsor model demonstration projects | _____ |
| c) Draw on a Federal clearinghouse to disseminate information on Federal R&D | _____ |
| d) Maintain a training program at the State and local level focused on Federal technology transfer and cooperation | _____ |

22. Provide comments and/or indicate other ways in which your organization does/could promote:

a) Federal technology transfer:

b) Technology transfer in general:

# APPENDIX C

## PROGRAM MANAGER'S QUESTIONNAIRE

Return to:

Marianne K. Clarke
National Governors' Association
444 North Capitol Street, NW, Suite 250
Washington, DC 20001

Code #

# A STUDY OF CURRENT STATE TECHNOLOGY EXTENSION SERVICES

## PROGRAM MANAGER'S QUESTIONNAIRE

Congress and the Administration have called upon the National Institute of Standards and Technology, formerly the National Bureau of Standards, to carry out a program of technology development and transfer in collaboration with industry, universities, other Federal agencies, and with State and local governments. Among the National Institute of Standards and Technology's new responsibilities outlined in the Technology [illegible]tiveness Act portion of the Trade Bill, is a Study of Current State Technology Extension Services. The Study is being undertaken jointly with the National Governors' Association (NGA) with advice and guidance from the NGA Working Group on State Initiatives in Applied Research.

The purpose of the Study is to provide an understanding of what each State is doing to promote technological innovation and job creation. This information will be useful to Congress in identifying a Federal role which is supportive of State efforts and will be of use to Governors in assessing the effectiveness of their technology extension efforts.

This questionnaire is designed for use by managers of a technology extension program. A separate, summary questionnaire, has been designed for use by State coordinators who may be responsible for a variety of programs in their State.

The questionnaire for this portion of the Study is divided into two parts:

1. Background Information
2. Program Orientation

Part 1 contains 2 sections. Part 1 is designed to collect information on your program and on its relationships with several key Federal programs. The two sections of Part 1 are entitled:

I. General Information
II. Relationships With Federally-Sponsored Programs

Part 2 contains 6 sections. Each section refers to a specific program focus. Only those sections which are of major importance to your program require a response. The six sections in Part 2 are concerned with the following extension program activities:

III. Business Assistance
IV. Incubators
V. Research Parks
VI. Seed Capital
VII. Technology Assistance
VIII. Technology/Research Centers

We would like to thank you in advance for your cooperation and support. We know that the completion of the questionnaire will require time and effort on your part but we believe the final product will be useful to you and your colleagues in other States. If you have any questions, please call Marianne Clarke at (202) 624-5380.

**PLEASE RETURN BY NOVEMBER 30, 1988**

This questionnaire was approved by the Office of Management and Budget (OMB) on September 28, 1988, OMB Control Number 0693-0007.

## PART 1: BACKGROUND INFORMATION

### SECTION I: GENERAL INFORMATION

1. Organization Name: _____

2. Administering Agency: _____

3. Address: a) _____

   b) _____

   c) _____

4. City: _____ 5. State: _____

6. Zip Code _____ 7. Date Established: _____

8. Director: _____

9. Title: _____

10. Telephone: _____

11. Principal Contact: _____

12. Title: _____

13. Telephone: _____

14. Telecopier: _____

15. Number of staff (full-time equivalent) employed (as of June 30, 1988):

    a) Professional (Technical): _____

    b) Professional (Business): _____

    c) Support Staff: _____

16. Organizational Objectives (50 words or less):

17. **Financial Data:** Estimate the total funds (including overhead and any other operating costs) received or anticipated (in thousands of $) by your organization by fiscal year from each of the sources listed below. Indicate when your fiscal year begins (_____).

| Source of Funds | Funds (thousands of $) | | | |
|---|---|---|---|---|
| | 1986 | 1987 | 1988 | 1989(est) |
| a) Federal Government | | | | |
| b) State Government | | | | |
| c) Local Government | | | | |
| d) University | | | | |
| e) Industry | | | | |
| f) All Other | | | | |
| TOTAL | | | | |

18. **Outreach:** Below is a list of strategies for increasing your clients awareness of how your program could benefit them. Indicate the importance of each strategy by showing how you would allocate $100 of program funds among them.

| Strategies | How would you allocate $100? |
|---|---|
| a) Advertising (e.g., journals, radio, trade associations, etc.) | _____ |
| b) Direct solicitation | _____ |
| c) Field agents | _____ |
| d) Networking (e.g., seminars, workshops, etc.) | _____ |
| e) Other (_____ _____) | _____ |

**Please use the following definitions in answering question 19.**

**Business Assistance:** Business assistance focuses on providing general business management information such as personnel, accounting and legal advice.
**Incubators:** Incubator facilities provide office and lab space for start-up companies at below-market rates. Shared support services such as clerical, reception and data processing are often made available.
**Research Parks:** Research parks are planned groupings of technology companies that encourage university/private relationships.
**Seed Capital:** Money is provided for projects that are at an early stage of development or that offer job creation potential but may not have the return on investment expected by commercial venture capitalists. Includes research grant and product development programs.
**Technology Assistance:** Technology assistance focuses on providing specialized services such as technical information, invention evaluation, technical counseling and patent infromation. Technology assistance includes both information exchange and active out-reach programs to provide access to newly-created technologies and to promote innovative applications of established technologies.
**Technology/Research Centers:** These centers generally concentrate their studies in a particular field which is usually based on the strengths of the university and/or the major industries in the State.

19. **Program Orientation:** Estimate the percent of staff resources allocated to each functional area during 1988. Estimate the percent of total funds allocated to each functional area during 1987, 1988 and 1989.

| Functional Area | Percent of Staff 1988 | Percent of Funds | | |
|---|---|---|---|---|
| | | 1987 | 1988 | 1989(est) |
| a) Business Assistance | | | | |
| b) Incubators | | | | |
| c) Research Parks | | | | |
| d) Seed Capital | | | | |
| e) Technology Assistance | | | | |
| f) Technology/Research Centers | | | | |
| g) Other: _____ _____ | | | | |
| TOTAL | 100 | 100 | 100 | 100 |

## SECTION II: RELATIONSHIPS WITH FEDERALLY-SPONSORED PROGRAMS

20. If your organization has used or been associated with a specific program, provide an assessment of how well that program complements your organization's objectives.

| Program Name | Have Used Program Y=Yes N=No | If Yes, Frequency of Use 1=Frequent 2=Sometimes 3=Seldom | If Yes, Program Assess. 1=Good 2=Fair 3=Poor |
|---|---|---|---|
| a) Center for Utilization of Federal Technology (Commerce/NTIS) | ☐ | ____ | ____ |
| b) Commercial Use of Space Program (NASA) | ☐ | ____ | ____ |
| c) Community Development Block Grants (HUD) | ☐ | ____ | ____ |
| d) Computer and Information Science and Engineering (NSF) | ☐ | ____ | ____ |
| e) Cooperative Extension Service (Agriculture) | ☐ | ____ | ____ |
| f) Energy Extension Service (Energy) | ☐ | ____ | ____ |
| g) Energy-Related Inventions (Energy and Commerce/NBS) | ☐ | ____ | ____ |
| h) Federal Laboratory Consortium (All) | ☐ | ____ | ____ |
| i) Industry/University Cooperative Research Centers (NSF) | ☐ | ____ | ____ |

20. (Continued)

| Program Name | Have Used Program Y=Yes N=No | If Yes, Frequency of Use 1=Frequent 2=Sometimes 3=Seldom | If Yes, Program Assess. 1=Good 2=Fair 3=Poor |
|---|---|---|---|
| j) Job Training Partnership Act (Labor) | ☐ | ____ | ____ |
| k) Measurement and Engineering Research Grants (Commerce/NBS) | ☐ | ____ | ____ |
| l) National Appropriate Technology Assistance Service (Energy) | ☐ | ____ | ____ |
| m) Office of Productivity, Technology and Innovation (Commerce) | ☐ | ____ | ____ |
| n) Office of Small and Disadvantaged Business Utilization (All) | ☐ | ____ | ____ |
| o) Patent and Trademark Office (Commerce) | ☐ | ____ | ____ |
| p) Program for Mathematics, Science, Computer Learning and Critical Foreign Languages (Education) | ☐ | ____ | ____ |
| q) Scientific, Technological and International Affairs (NSF) | ☐ | ____ | ____ |
| r) SCORE/ACE (SBA) | ☐ | ____ | ____ |
| s) Small Business Development Center Program (SBA) | ☐ | ____ | ____ |
| t) Small Business Innovation Research Program (All) | ☐ | ____ | ____ |

20. (Continued)

| Program Name | Have Used Program Y=Yes N=No | If Yes, Frequency of Use 1=Frequent 2=Sometimes 3=Seldom | If Yes, Program Assess. 1=Good 2=Fair 3=Poor |
|---|---|---|---|
| u) Small Business Investment Companies (SBA) | ☐ | ____ | ____ |
| v) Technology Utilization Program (NASA) | ☐ | ____ | ____ |
| w) Trade Adjustment Assistance Centers Program (Commerce/ITA) | ☐ | ____ | ____ |
| x) Trade Adjustment Assistance Workers (Labor) | ☐ | ____ | ____ |
| y) University Centers Program (Commerce/EDA) | ☐ | ____ | ____ |
| Other Federal Programs (Please List) | | | |
| aa)_____ _____ | ☐ | ____ | ____ |
| bb)_____ _____ | ☐ | ____ | ____ |
| cc)_____ _____ | ☐ | ____ | ____ |

21. Below is a list of strategies through which your organization does or could facilitate the transfer of Federal scientific and technical information, including the results and application of Federal and Federally-funded research/technology. Indicate the importance of each strategy by showing how you would allocate $100 of program funds among them.

| Strategies | How would you allocate $100? |
|---|---|
| a) Cooperate actively with Federal agencies in their technology transfer programs | _____ |
| b) Cosponsor model demonstration projects | _____ |
| c) Draw on a Federal clearinghouse to disseminate information on Federal R&D | _____ |
| d) Maintain a training program at the State and local level focused on Federal technology transfer and cooperation | _____ |

22. Provide comments and/or indicate other ways in which your organization does/could promote:

a) Federal technology transfer:

b) Technology transfer in general:

## PART 2: PROGRAM ORIENTATION

### SECTION III: BUSINESS ASSISTANCE

**Answer questions 23 through 27 if your organization provides business assistance.**

23. **Type of Service:** Check the box in Column 1 if your organization provided that service during 1985, 1986 or 1987. Check the box in Column 2 if your organization is currently providing that service. Check the box in Column 3 if your organization is either providing that service at an increased level or is planning an expansion in 1989.

| Type of Service | Column 1 Provided 85, 86, 87 | Column 2 Provided 88 | Column 3 Expanded 88 or 89 |
|---|---|---|---|
| a) Business Forecasting | ☐ | ☐ | ☐ |
| b) Business Plan Preparation/Evaluation | ☐ | ☐ | ☐ |
| c) Feasibility Studies | ☐ | ☐ | ☐ |
| d) Financial Analysis | ☐ | ☐ | ☐ |
| e) Joint Venture/Partnership Counseling | ☐ | ☐ | ☐ |
| f) Labor Analysis | ☐ | ☐ | ☐ |
| g) Management Assistance and Studies | ☐ | ☐ | ☐ |
| h) Marketing Surveys | ☐ | ☐ | ☐ |
| i) Site Location Assistance | ☐ | ☐ | ☐ |
| j) Small Business Consulting | ☐ | ☐ | ☐ |

24. Estimate the number of establishments assisted:

a) 1985: _____
b) 1986: _____
c) 1987: _____
d) 1988: _____
e) 1989: _____

25. **Establishment Data:** Estimate the number of establishments assisted by your organization during 1988. Please classify establishments by type (manufacturing versus non-manufacturing) and size. An establishment, as defined by the Census, counts each store, office, or plant with one or more employees as a separate entity. Non-manufacturing establishments are those major industry groups involved in: agriculture, mining, construction, and services (transportation, finance, government enterprises, etc.).

| Type of Establishment | Number of Establishments | | | | TOTAL |
|---|---|---|---|---|---|
| | Less than 50 | Between 50 & 500 | More than 500 | Don't Know | |
| Manufacturing | | | | | |
| Non-Manufacturing | | | | | |
| Don't Know | | | | | |
| TOTAL | | | | | |

26. **Assistance to Individuals:** Estimate the number of individuals assisted (e.g., innovators, entrepreneurs, etc.) during 1988: _____.

27. Percentage of establishments assisted during 1988 which required access to:

a) Newly-created technologies: _____
b) Established technologies: _____

## SECTION IV: INCUBATORS

Answer questions 28 through 32 if your organization supports incubators.

28. Provide estimates of the following background statistics:

| | Number of Incubators | Number of Establish-ments | Number of Employees | Number of Graduates |
|---|---|---|---|---|
| a) 1985: | _____ | _____ | _____ | _____ |
| b) 1986: | _____ | _____ | _____ | _____ |
| c) 1987: | _____ | _____ | _____ | _____ |
| d) 1988: | _____ | _____ | _____ | _____ |
| e) 1989: | _____ | _____ | _____ | _____ |

29. Percentage of establishments incubated during 1988 which required access to:

a) Newly-created technologies: _____
b) Established technologies: _____

30. Percentage breakdown by type of technology targeted during 1988:

a) Aerospace: _____
b) Biotechnology and Life Sciences: _____
c) Earth Sciences: _____
d) Information Technologies: _____
e) Manufacturing Technologies: _____
f) Materials Sciences: _____
g) Other (_____

_____): _____

31. Number of years an establishment spends in an incubator:

a) Average: _____
b) Maximum: _____

32. Percentage of establishments graduated between 1985 and 1987 which:

a) Are Still in Business: _____
b) Are No Longer in Business: _____
c) Don't Know: _____

## SECTION V: RESEARCH PARKS

**Answer questions 33 through 35 if your organization supports research parks.**

33. Provide estimates for the following background statistics:

| | Number of Parks | Percent of Available Space Occupied (Square Feet) |
|---|---|---|
| a) 1985: | _____ | _____ |
| b) 1986: | _____ | _____ |
| c) 1987: | _____ | _____ |
| d) 1988: | _____ | _____ |
| e) 1989: | _____ | _____ |

34. Provide estimates for the following establishment statistics:

| | Number of Establishments | Number of Employees |
|---|---|---|
| a) 1985: | _____ | _____ |
| b) 1986: | _____ | _____ |
| c) 1987: | _____ | _____ |
| d) 1988: | _____ | _____ |
| e) 1989: | _____ | _____ |

35. Percentage breakdown by type of technology targeted during 1988:

a) Aerospace: _____
b) Biotechnology and Life Sciences: _____
c) Earth Sciences: _____
d) Information Technologies: _____
e) Manufacturing Technologies: _____
f) Materials Sciences: _____
g) Other (_____

_____): _____

## SECTION VI: SEED CAPITAL

**Answer questions 36 through 41 if your organization provides seed capital.**

36. **Establishments assisted:**

| Year | Number of Establish-ments | Public (thousands of $) | | Private (thousands of $) |
|---|---|---|---|---|
| | | Pension | Other | |
| 1985 | | | | |
| 1986 | | | | |
| 1987 | | | | |
| 1988 | | | | |
| 1989 | | | | |

37. **Establishment Data:** Estimate the number of establishments assisted by your organization during 1988. Please classify establishments by type (manufacturing versus non-manufacturing) and size. An establishment, as defined by the Census, counts each store, office, or plant with one or more employees as a separate entity. Non-manufacturing establishments are those major industry groups involved in: agriculture, mining, construction, and services (transportation, finance, government enterprises, etc.).

| Type of Establishment | Number of Establishments | | | | TOTAL |
|---|---|---|---|---|---|
| | Less than 50 | Between 50 & 500 | More than 500 | Don't Know | |
| Manufacturing | | | | | |
| Non-Manufacturing | | | | | |
| Don't Know | | | | | |
| TOTAL | | | | | |

38. Percentage of establishments assisted between 1985 and 1987 which:

a) Are Still in Business: _____
b) Are No Longer in Business: _____
c) Don't Know: _____

39. Percentage of establishments assisted during 1988 which required access to:

a) Newly-created technologies: _____
b) Established technologies: _____

40. Percentage breakdown by type of technology targeted during 1988:

a) Aerospace: _____
b) Biotechnology and Life Sciences: _____
c) Earth Sciences: _____
d) Information Technologies: _____
e) Manufacturing Technologies: _____
f) Materials Sciences: _____
g) Other (_____

_____): _____

41. Percentage breakdown by type of funds provided during 1988:

a) Product/process development: _____
b) Product/process testing: _____
c) Prototype development: _____
d) Product/process commercialization: _____
e) Other: _____

## SECTION VII: TECHNOLOGY ASSISTANCE

**Answer questions 42 through 48 if your organization provides technology assistance.**

42. **Type of Service:** Check the box in Column 1 if your organization provided that service during 1985, 1986 or 1987. Check the box in Column 2 if your organization is currently providing that service. Check the box in Column 3 if your organization is either providing that service at an increased level or is planning an expansion in 1989.

| Type of Service | Column 1 Provided 85, 86, 87 | Column 2 Provided 88 | Column 3 Expanded 88 or 89 |
|---|---|---|---|
| a) Demonstration Projects | ☐ | ☐ | ☐ |
| b) Joint Venture/Partnership Counseling | ☐ | ☐ | ☐ |
| c) Networking & Referrals | ☐ | ☐ | ☐ |
| d) Product Design and/or Evaluation | ☐ | ☐ | ☐ |
| e) Seminars/Workshops | ☐ | ☐ | ☐ |
| f) State liaison to Federal Labs | ☐ | ☐ | ☐ |
| g) Technical Counseling | ☐ | ☐ | ☐ |
| h) Technical Data Services | ☐ | ☐ | ☐ |
| i) Technical literature dissemination/review | ☐ | ☐ | ☐ |
| j) User request and response | ☐ | ☐ | ☐ |

43. Estimate the number of establishments assisted:

a) 1985: _____
b) 1986: _____
c) 1987: _____
d) 1988: _____
e) 1989: _____

44. **Establishment Data:** Estimate the number of establishments assisted by your organization during 1988. Please classify establishments by type (manufacturing versus non-manufacturing) and size. An establishment, as defined by the Census, counts each store, office, or plant with one or more employees as a separate entity. Non-manufacturing establishments are those major industry groups involved in: agriculture, mining, construction, and services (transportation, finance, government enterprises, etc.).

| Type of Establishment | Number of Establishments | | | | TOTAL |
|---|---|---|---|---|---|
| | Less than 50 | Between 50 & 500 | More than 500 | Don't Know | |
| Manufacturing | | | | | |
| Non-Manufacturing | | | | | |
| Don't Know | | | | | |
| TOTAL | | | | | |

45. **Assistance to Individuals:** Estimate the number of individuals assisted (e.g., innovators, entrepreneurs, etc.) during 1988: _____.

46. Percentage of establishments assisted during 1988 which required access to:

a) Newly-created technologies: _____
b) Established technologies: _____

47. Percentage breakdown by type of technology targeted during 1988:

a) Aerospace: _____
b) Biotechnology and Life Sciences: _____
c) Earth Sciences: _____
d) Information Technologies: _____
e) Manufacturing Technologies: _____
f) Materials Sciences: _____
g) Other (_____

_____): _____

48. Percentage breakdown by type of assistance provided during 1988:

a) Product/process development: _____
b) Product/process testing: _____
c) Prototype development: _____
d) Product/process commercialization: _____
e) Other: _____
_____

## SECTION VIII: TECHNOLOGY/RESEARCH CENTERS

**Answer questions 49 and 50 if your organization supports technology centers or research centers.**

49. Provide estimates for the following background statistics:

| | Number of Centers | Number of Establishments Participating |
|---|---|---|
| a) 1985: | _____ | _____ |
| b) 1986: | _____ | _____ |
| c) 1987: | _____ | _____ |
| d) 1988: | _____ | _____ |
| e) 1989: | _____ | _____ |

49. Background statistics (continued):

| | Number of Small and Medium-sized Establishments | Number of Manufacturing Establishments |
|---|---|---|
| a) 1985: | _____ | _____ |
| b) 1986: | _____ | _____ |
| c) 1987: | _____ | _____ |
| d) 1988: | _____ | _____ |
| e) 1989: | _____ | _____ |

50. Percentage breakdown by type of technology targeted during 1988:

a) Aerospace: _____
b) Biotechnology and Life Sciences: _____
c) Earth Sciences: _____
d) Information Technologies: _____
e) Manufacturing Technologies: _____
f) Materials Sciences: _____
g) Other (_____

_____): _____

Federal Register
MAY 26

American Association For Laboratory Accreditation

April 20, 1989

Honorable Doug Walgren
Chairman, Subcommittee on Science and Technology
Committee on Science, Space and Technology
Rayburn House Office Building, Suite 2321
Washington DC 20515

Dear Congressman Walgren:

The American Association for Laboratory Accreditation (A2LA) thanks you for the opportunity to present its views on the Standardization of Measurement Act of 1989.

We would like to make one point more clearly. A2LA is a voluntary standards body, similar in composition to ASTM, ASME, SAE, etc. The standards we set are specific criteria that our laboratories must meet in order to be accredited. These criteria are prepared by an advisory committee (of which any interested party may be a part), voted on by our Criteria Council, and finally approved by our Board of Directors. An example of such specific requirements is shown in Attachment 1 for metals testing laboratories.

An organization chart is shown as Attachment 2. I would like to summarize the backgrounds of these people.

- Three are federal government employees: One from DOD, one from FDA, and one from NIOSH. In addition, we have a liaison member of the Board from EPA.
- One is a representative of state and local government officials: Council of American Building Officials.
- One is a representative of organized labor: AFL/CIO
- One is from a major equipment manufacturer: General Motors
- Three are representatives of suppliers to major equipment manufacturers: Dupont, Allegheny Ludlum, and JSX.
- Three are representatives of commercial laboratories: Standard Laboratories, Lancaster Laboratories, and Hauser Laboratories.
- Two are from nonprofit research laboratories: Syracuse Research and Factory Mutual.
- Three are consultants; Howard Forman, David MacLean, and Robert Peach -- all well respected in various fields.
- One represents an association with a similar program in the medical field: College of American Pathologists

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Members of the Board do not have to be members of the Association, but are elected to the Board by the members. Eight of the 17 members of the Board are members of the Association.

Some members of the Board have laboratories accredited. General Motors (GM) has a number of accredited laboratories; GM insists that their supplier laboratories be accredited and to show the way, have had their own laboratories accredited. Dupont, a GM supplier, is accredited. Two of the three commercial laboratories are accredited. DOD has three accredited laboratories. Five members of the Board are from organizations that have accredited laboratories.

Decisions on accreditation are not made by the Board. Their primary role is to set policy and oversee management of the operation. The Board can be called upon to review an appeal should a laboratory question the decision of the Accreditation Council, but no such appeal has been received to date. Members who have any conflict will abstain in any such appeal process.

The three-person staff, which manages the Association, has a combined total of 36 years experience in operating laboratory accreditation systems. For 27 of those years, the experience was at the National Institute of Standards and Technology. They all have well-respected names in laboratory accreditation, both in the United States (two are chairmen of an ASTM committee and subcommittee related to laboratory accreditation) and internationally.

The A2LA Board is organized as almost every other voluntary standards body. Clearly, ASME Board members can represent organizations directly affected by the standards they develop. In a similar way, there could be some conflict between certified/accredited organizations and Board members.

We would be pleased to offer you additional information about our Association to clarify any other misinterpretations that may be made.

Sincerely,

John W. Locke

John W. Locke
President

cc: Executive Committee

Attachment 1

# American Association For Laboratory Accreditation

METALS TESTING PROGRAM REQUIREMENTS
MARCH 1989

INTRODUCTION

These accreditation requirements are specifically applicable to the special metals laboratory accreditation program in support of the needs of the Defense Industrial Supply Center (DISC). They cover tests under the American Association for Laboratory Accreditation (A2LA) Chemical and Mechanical Fields of Testing.

Internationally accepted accreditation criteria, accreditation guidance documents developed by standards organizations such as ASTM, individual user requirements such as those of DISC, and test method standards form the basis for this program. The requirements as presented were developed by the A2LA Metals Advisory Committee.

One of the major objectives of this program is to provide those responsible for using or approving metals testing laboratories with an effective and efficient alternative to their own action of evaluating and recognizing qualified laboratories. A thorough and balanced assessment is provided as these requirements are coordinated with A2LA requirements in other areas to provide overall accreditation of a laboratory with a minimum disruption to laboratory operations. A2LA is committed to working with government and non-government users, purchasing officials, and program managers to provide accreditation over an appropriate scope to realize this objective.

The program focusses on the following types of tests:

1. Chemical Analysis

   a. Ferrous: carbon and alloy steels, high strength steels (carbon and low alloy), heat and corrosion resistant steels (including stainless), tool steels, maraging steels, etc.
   b. Non-Ferrous: aluminum and aluminum alloys, copper and copper alloys, nickel and nickel alloys, zinc and zinc alloys, titanium and titanium alloys, magnesium and magnesium alloys, precious metals and alloys, etc.

2. Mechanical Testing

   a. Tension: tensile strength, yield strength, elongation and reduction of area.
   b. Hardness: Rockwell, Brinell, and microhardness (Knoop and Vickers).

Other types of tests, including dimensional tests, metallurgical services, corrosion tests, nondestructive tests, and failure analysis, can also be requested.

C37m031689 - draft #7

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Applications for accreditation may be made for one or more specific test technologies or methods. For the chemical analysis of metals, no attempt is made to list all of the various methods used. Any acceptable method or technique can be employed provided it conforms to a recognized standard, such as ASTM, and/or it can be demonstrated (using certified reference materials, proficiency testing, etc.) that acceptable precision and bias levels can be obtained. For mechanical tests, the method or technique employed shall be performed on acceptable equipment (properly calibrated) and should conform to a recognized standard, such as ASTM.

SPECIFIC REQUIREMENTS OF THE METALS TESTING PROGRAM

Overview

The A2LA accreditation process and general requirements for accreditation are described in the A2LA General Requirements for Accreditation booklet.

Test Methods

If accreditation is sought to support an existing government or private sector user requirement, then the laboratory is expected to use the user's designated test methods. If a laboratory wishes accreditation for the use of its own methods, then it must be prepared to produce acceptable results. Information such as the following should be available:

- origin of method;
- departures from standard;
- reason for departures;
- effects of departures; and
- comparison with the standard methods they replace.

Accreditation cannot be granted for test methods which are proprietary.

The laboratory is requested to identify before the on-site assessment the specific types of tests for which it seeks accreditation. In applying, the laboratory is requested to consult the CHEMICAL/MECHANICAL (METALS OR METAL FASTENERS) FIELD OF TESTING SELECTION LISTS as basic references or points of departure in identifying the methods for which it seeks accreditation.

Proficiency Testing

Applicants are required to participate in at least one relevant and available proficiency testing program administered by organizations acceptable to A2LA Headquarters.[1] The results are provided to A2LA by the administering organization and should any of the laboratory's results be deemed outliers or unacceptable, then the laboratory must investigate and determine the cause(s) for such unacceptable results, correct any problems, and provide evidence that such problems have been corrected.

---

[1] One acceptable metal proficiency program is administered by Collaborative Testing Services, Inc., P.O. Box 1049, Herndon, VA 22070; (703) 481 1125.

CRITERIA FOR ACCREDITATION

1.0 General.

The "General Requirements for the Technical Competence of Testing Laboratories (ISO/IEC Guide 25-1982)" contained in Appendix A and the "Conditions for Accreditation" (based on ISO/IEC Guide 38) apply. These general criteria have been augmented by additional specific requirements apply as described below. For ease of relating the specific requirements to the general requirements, the numbering system for the general requirements, Appendix A will be used as a basis for departure in numbering the specific criteria which follow.

2.0 Specific.

Specific criteria are an elaborstion on or interpretation of the general criteria plus those special requirements of accreditation applicable to a certain field of testing, testing technology, type of test, or specific test or program. These special criteria normally come from other standards[2,3,4,5,6] or documents that apply to specific areas and that have been recommended for inclusion in specific programs by appropriate A2LA advisory committees.

3.0 Organization. The general criteria (Appendix A) apply.

4.0 Quality System. The general criteria apply with the following additions:

Under 4.2:

- list of standards and frequency of use to either calibrate, standardize, or verify the equipment.
- list of reference materials and frequency of use to substantiate correct procedure/operation.
- standard arrangements for feedback and corrective actions
- For steel testing laboratories (Ref. 2):
  - o Methods of inspection and measurement. (7.1.3.1, Ref. 2)

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2 ASTM A880-88. Practice for Criteria for Use in Evaluation of Testing Laboratories and Organizations for the Examination and Inspection of Steel, Stainless Steel, and Related Alloys.

3 ASTM E743-80 (85). Guide for Spectrochemical Laboratory Quality Assurance.

4 ASTM E807-81 (86). Practice for Metallographic Laboratory Evaluation.

5 ASTM E851-81 (85). Practice for Evaluation of Spectrochemical Laboratories

6 ASTM E882-87. Guide for Accountability and Quality Control in the Chemical Analysis Laboratory.

- o Traceability of samples and data through receiving to final data. (7.1.3.2)
- o Procedure for sample preparation. (7.1.3.3)
- o Internal audits of samples and test data. (7.1.3.4)
- o Corrective action. (7.1.3.5)
- o Quality control program. (7.1.3.6)
- o Quality assurance program, to assure that small tools (micrometers, dial gages, gage-mark punches, etc.) are accurate. (7.1.3.7)

- For spectrochemical laboratories (References 3 and 5):
  - o Whenever possible, routine methods of analysis should be based on standard methods (for example ANSI, ASTM, AOAI, etc.) suitably adapted to specific materials, instrumentation, and analytical requirements. (6.2, Ref.3)
  - o Procedures to monitor the precision and accuracy of the analytical methods should be established by those who audit the quality assurance system. These procedures should document traceability to suitable reference materials. (6.5, Ref.3)
  - o The instrument must be calibrated when installed, after major repairs are made, or as indicated by standardization checks. (7.1, Ref. 3)
  - o Records of standardization runs and adjustments must be maintained. Such records should include the reference materials used, their certified value, and values obtained by the spectrochemical laboratory. The date, shift, and analyst should be recorded. (7.5, Ref. 3)
  - o An internal audit should be established to monitor the quality assurance procedures. (10.1, Ref. 3)
  - o A system of verification of analyses should be maintained. Common techniques involve the analysis of duplicate specimens by other analysts, methods, or laboratories. (10.2, Ref. 3)
  - o Records must include control sample values, comparisons with assumed true values, reference material values, and corrective action taken. (10.3, Ref. 3)
  - o Frequency of calibration, calibration procedure, and copies of calibration curves for each spectrochemical instrument and support equipment (for example, analytical balances). (10.2.1, Ref. 5)
  - o Frequency of standardization, standardization procedure, and a log of recent standardization runs and corrective action taken for each spectrochemical instrument. (10.2.2, Ref. 5)
  - o Relationship of the assumed concentration of "inhouse" or other reference materials to certified reference materials. (10.2.3, Ref. 5)
  - o Procedures used to test and accept the homogeneity of material used for "inhouse" reference materials. (10.2.4, Ref. 5)
  - o Methods of data recording, processing, and reporting. (10.2.5 Ref. 5)
  - o If applicable, procedures for calculating coefficients to mathematically define calibration curves. (10.2.6, Ref. 5)

- o Methods of sampling and preparation to obtain a specimen for analysis. (10.2.7, Ref. 5)
- o Procedures used to monitor the precision and accuracy of the analytical methods, and recent performance data to confirm that satisfactory analytical performance is being provided. (10.2.8, Ref. 5)
- o Procedures for detecting and reporting analytical discrepancies, correcting the problem and logging the cause, and corrective action taken for future reference. (10.2.10, Ref. 5)
- o Procedures for internal audit of the laboratory to assure that analytical procedures are followed and performance meets specifications. (10.2.11, Ref. 5)
- o Frequency of internal audits, reports of findings, and corrective action taken. (10.2.12, Ref. 5)

- For metallographic laboratories (Reference 4):
  - o Basic plan of the quality assurance system used, including:
    - . Basis for specimen sampling of the material received by the agency.
    - . Methods of analysis of data.
    - . A report of any significant discrepancies when detected, with an assignable cause, where possible.
    - . Internal agency review. (9.1.1, Ref. 4)
  - o Basic plan of the measuring systems used, including:
    - . Calibration programs.
    - . Standardization of methods of test, measurement, and determination.
    - . Traceability or credibility, or both (as applicable), of physical and numerical standards used.
    - . Methods of data recording and retention.

5. Staff. The general criteria apply with the following addition:

New 5.6 Periodic review or other assurance that the employee's technical competence is maintained.

6. Testing and Measuring Equipment. The general criteria apply with the following additions:

New 6.7 The laboratory shall have:
- documentation that ensures satisfactory performance of newly installed instrumentation;
- clearly defined and written maintenance procedures for each measurement system and required support equipment;
- maintenance records for each maintenance activity.

New 6.8 For spectrochemical laboratories (7.2 & 7.3, Ref. 3):
- The instrument should be standardized as frequently as performance experience indicates.
- Determination and interpretation of precision and accuracy are supervisory responsibilities.

7. Calibration. The general criteria apply with the following additions:

New 7.7 Compliance certificates should be either on file or traceable to the equipment or displayed by each piece of equipment. (7.1.1.2, Ref. 2)

New 7.8 For steel laboratories additional information, as applicable, shall be made available for on-site evaluation: (7.1, Ref.2):

- Systems of metrology employed, such as:
  - o Testing, examination, and inspection equipment.
  - o Compliance programs.
  - o Traceability of calibration standards (chemical, physical, mechanical).

8. Test Methods and Procedures. The general criteria apply with the following addition:

New 8.6 The laboratory shall have:

- Procedures for making and controlling revisions to methodology (use revised methods only after written authorization by senior technical personnel).
- Documented procedures for data handling, reporting and record keeping.
- Documented validation procedures to apply at appropriate levels of all measurement processes.
- Documented procedures to check the validity of reported analysis values.
- Documented procedures for correcting erroneously reported results.

New 8.7 For spectrochemical laboratories:

- Written procedures for calibration and standardization should be available. (7.4, Ref. 3)

9. Environment. The general criteria apply.

10. Handling Items to be Tested. The general criteria apply.

11. Records. The general criteria apply with the following addition:

New 11.3 The records shall be retained in separate storage areas with appropriate environmental controls.

12. Test Reports. The general criteria apply with the following addition:

Add to 12.2:

- Inform clients of any tests in their accredited scope which have been subcontracted to another organization.

Some duplication exists in the above specific requirements because the provisions have been taken from different standards.



98-198 0 - 89 - 31

APPENDIX A

## GENERAL REQUIREMENTS FOR THE TECHNICAL COMPETENCE OF TESTING LABORATORIES (ISO/IEC Guide 25-1982)

### 1. Scope and Field of Application

The object of this document is to set forth only the general requirements with which a testing laboratory shall comply if it is to be recognized as technically competent.

Additional requirements and information which must be disclosed for assessing technical competence or for determining compliance with other criteria may be specified, depending upon the specific character of the task of the laboratory.

As used herein, a testing laboratory refers to that facility which is operated at or from a specifically designated location.

### 2. Definitions

The following definitions, taken from ISO Guide 2, are applicable:

2.1 **testing laboratory:** A laboratory which measures, examines, tests, calibrates or otherwise determines the characteristics or performance of materials or products.

2.2 **test method:** A defined technical procedure to determine one or more specified characteristics of a material or product.

2.3 **test report:** A document which presents the test results and other information relevant to the test.

2.4 **accrediting body:** A governmental or non-governmental body which conducts and administers a laboratory accreditation system and grants accreditation.

2.5 **certification body:** An impartial body, governmental or non-governmental, possessing the necessary competence and reliability to operate a certification system, and in which the interests of all parties concerned with the functioning of the system are represented.

### 3. Organization

The testing laboratory shall

- be legally identifiable;
- have an organizational structure, including quality system, that enables it to maintain the capability to perform satisfactorily the technical functions for which recognition is granted;

- be able to demonstrate, on request from the persons or organizations assessing its competence, that it is capable of performing the tests representative of those for which it is seeking recognition;
- be organized so as not to subject staff members to undue pressure or inducement that might influence their judgment or results of their work;
- be organized in such a way that each staff member is aware of both the extent and the limitations of his area of responsibility;
- have a technical manager (however named) who has overall responsibility for the technical operations of the laboratory;
- have adequate security rules and measures for protection of proprietary rights and confidential information.

NOTE - In small laboratories, the organizational structure may fulfill the requirements of this clause in a simplified way.

4. Quality System

4.1 The laboratory shall operate an internal quality assurance program appropriate to the type, range and volume of work performed. The quality assurance program shall be documented in a quality manual which is available for use by the laboratory staff. The quality manual shall be maintained relevant and current by a responsible member of the laboratory staff.

A person or persons having responsibility for quality assurance within the laboratory shall be designated by the laboratory management and have direct access to top management.

4.2 The quality manual shall contain information regarding:

- the structure of the laboratory (organizational charts);
- the operational and functional duties and services pertaining to quality, so that each person concerned will know the extent and the limits of his responsibility;
- general quality assurance procedures;
- quality assurance procedures specific for each test, as appropriate;
- where appropriate, proficiency testing, use of reference material, etc.;
- satisfactory arrangements for feedback and corrective action whenever testing discrepancies are detected;
- procedure for dealing with technical complaints.

4.3 The quality system shall be systematically and periodically reviewed by or on behalf of management to ensure the continued effectiveness of the arrangements, and corrective action initiated. Such reviews shall be recorded together with details of any corrective action taken.

NOTE - In small laboratories, the quality system may fulfill the requirements of this clause in a simplified way.

5. Staff

5.1 Staff shall have the necessary education, training, technical knowledge and experience for their assigned functions.

5.2 There shall be a job description for each senior technical position category, which includes the necessary education, training, technical knowledge and experience.

5.3 The proportion of supervisory to non-supervisory staff shall be such as to ensure adequate supervision.

5.4 Suitable staff shall be nominated to deputize for the senior technical and quality system management staff in their absence.

5.5 Information on the relevant qualifications, training and experience of the technical staff shall be maintained by the laboratory.

NOTE - In small laboratories, one person may fulfill more than one function.

6. Testing and Measuring Equipment

6.1 The testing laboratory shall be furnished with or have access to all items of equipment required for correct performance of the tests and measurements for which it is recognized.

6.2 All equipment shall be properly maintained to ensure protection from corrosion and other causes of deterioration. Instructions for a proper maintenance procedure for those items of equipment which require periodical maintenance shall be available.

6.3 Any item of the equipment which has been subjected to overloading or mishandling, or which gives suspect results, or has been shown by calibration or otherwise to be defective, shall be taken out of service and clearly labelled until it has been repaired and then shown by test or calibration to be performing its function satisfactorily.

6.4 Records shall be maintained of each major item of equipment. Each record shall include:

6.4.1 The name of the item of equipment.
6.4.2 The manufacturer's name and type identification and serial number.
6.4.3 Date received and date placed in service.
6.4.4 Current location, where appropriate.
6.4.5 Details of maintenance.

6.5 In the case of measuring equipment, the record shall also include:

6.5.1 Date of last calibration and calibration reports.
6.5.2 The maximum period of time between successive calibrations.

6.6 A label or tag indicating the date of the last calibration and the due date of the next calibration should be attached to equipment requiring calibration.

## 7. Calibration

7.1 Measuring and testing equipment used in the testing laboratory shall be calibrated where appropriate before being put into service and thereafter according to an established program.

7.2 The overall program of calibration of equipment shall be designed and operated so as to ensure that measurements made in the testing laboratory are traceable (where the concept is applicable) to national standards of measurement and, where available, to international standards of measurement specified by the International Committee of Weights and Measures. Where the concept of traceability to national or international standards of measurement is not applicable, the testing laboratory shall provide satisfactory evidence of correlation or accuracy of test results (for example by participation in a suitable program of interlaboratory comparisons).

7.3 Reference standards of measurement held by the laboratory shall be used for calibration only and for no other purpose.

7.4 Reference standards of measurement shall be calibrated by a competent body that can provide traceability to a national or international standard of measurement.

7.5 Where relevant, in-service testing equipment shall be subjected to checks between regular recalibrations.

7.6 Reference materials shall where possible be traceable to national or international standard reference materials.

## 8. Test Methods and Procedures

8.1 The testing laboratory shall have adequate documented instructions on the use and operation of all relevant equipment, on the handling and preparation of test items (where applicable), and on standard testing techniques, where the absence of such instructions could jeopardize the efficacy of the testing process. All instructions, standards, manuals and reference data relevant to the work of the testing laboratory shall be maintained up-to-date and be readily available to the staff.

8.2 The testing laboratory shall use methods and procedures required by the specification against which the test items are to be tested. The specification shall be available to staff performing the test.

8.3 Where it is necessary to employ test methods and procedures which are non-standard, these shall be fully documented.

8.4 All manual calculation and data transfers shall be subject to appropriate checks.

8.5 Where these results are derived by electronic data processing techniques, the stability of the system shall be such that the accuracy of the results is not affected. This generally implies an ability to detect malfunctions in the hardware during program execution and take appropriate action.

## 9. Environment

9.1 The environment in which the tests are undertaken shall not invalidate the test results or adversely affect the required accuracy of measurement. The testing premises shall be protected as required from excessive conditions such as excessive temperature, dust, moisture, steam, vibration, electromagnetic disturbance, interference, and shall be maintained accordingly. They shall be sufficiently spacious to limit the risk of damage or danger and to allow operators to make practical and precise movements. The premises shall have the equipment and energy sources needed for the testing. When the testing so requires, they shall be equipped with devices to monitor the environmental conditions.

9.2 Access to and use of all test areas shall be controlled in a manner appropriate to their designated purpose and entry by persons external to the laboratory shall be denied.

9.3 Adequate measures shall be taken to ensure good housekeeping in the testing laboratory.

## 10. Handling of Items to be Tested

10.1 A system for identifying the samples or items to be tested or calibrated shall be applied, either through documents or through marking, to ensure that there can be no confusion regarding the identity of the samples or test items and the results of the measurements made.

10.2 A procedure shall exist for bonded storage of items where necessary.

10.3 At all stages of storing, handling and preparation for test precautions shall be taken to prevent damage to the items, for example contamination, corrosion or the application of stresses, any of which would invalidate the results. Any relevant instructions provided with the item shall be observed.

10.4 There shall be clear rules for the receipt, retention and disposal of samples.

## 11. Records

11.1 The testing laboratory shall maintain a record system to suit its particular circumstances and comply with any existing regulations. It shall

retain on record all original observations, calculations and derived data, calibration records and the final test report for an appropriate period. The records for each test must contain sufficient information to permit satisfactory repetition of the test.

NOTE - In some countries it may be necessary to maintain records for a period specified by law.

11.2 All records and test reports shall be held secure and in confidence to the client, unless otherwise required by law.

## 12. Test Reports

12.1 The work carried out by the testing laboratory shall be covered by a report which accurately, clearly and unambiguously presents the test results and all other relevant information.

12.2 Each test report shall include at least the following information:

- name and address of testing laboratory;
- unique identification of report (such as serial number), and of each page of the report;
- name and address of client;
- description and identification of the test item;
- date of receipt of test item and date(s) of performance of test, as appropriate;
- a statement to the effect that the test results relate only to the items tested;
- identification of the test specification, method and procedure;
- description of sampling procedure, where relevant;
- any deviations, additions to or exclusions from the test specification, and any other information relevant to a specific test;
- disclosure of any non-standard test method or procedure utilized;
- measurements, examinations and derived results, supported by tables, graphs, sketches, and photographs as appropriate, and any failures identified;
- a statement on measurement uncertainty (where relevant);
- a signature and title of person(s) accepting technical responsibility for the test report and date of issue;
- a statement that the report shall not be reproduced except in full without the approval of the testing laboratory.

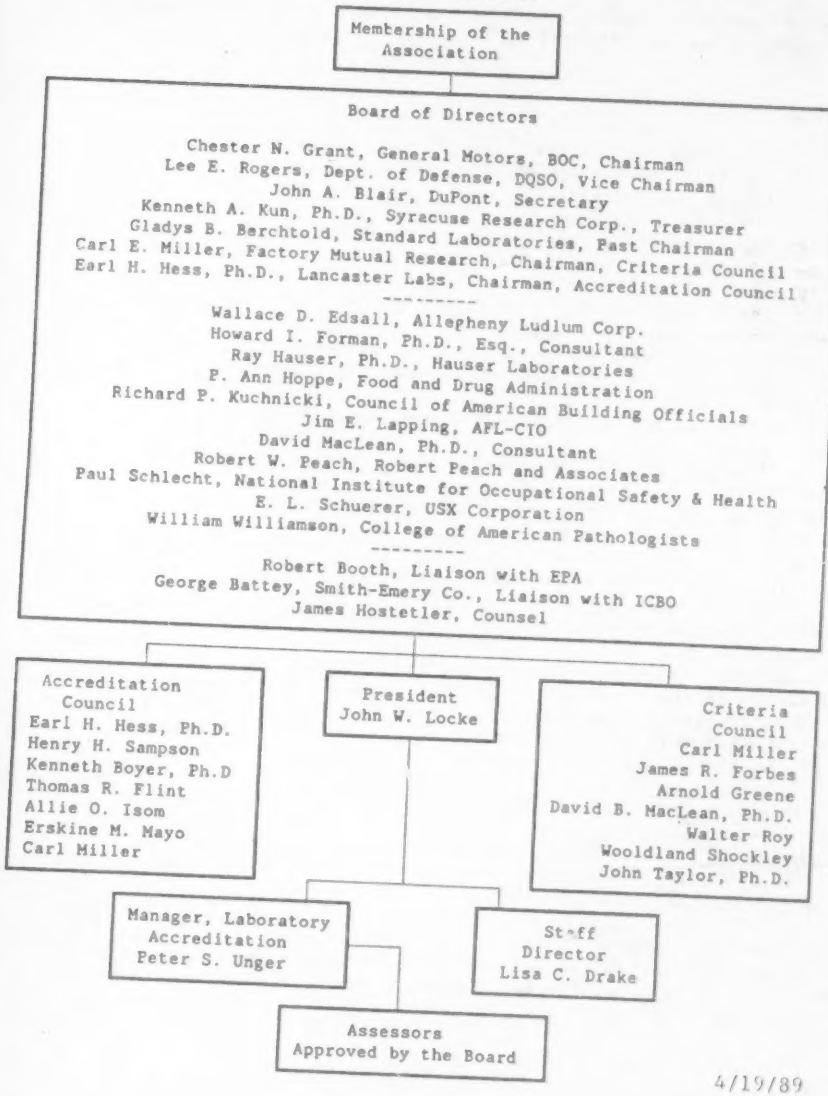
12.3 Particular care and attention shall be paid to the arrangement of the test report, especially with regard to presentation of the test data and ease of assimilation by the reader. The format shall be carefully and specifically designed for each type of test carried out, but the headings shall be standardized as far as possible.

12.4 Corrections or additions to a test report after issue shall be made only by a further document suitably marked, e.g., "Supplement to test report serial number ... (or as otherwise identified)", and shall meet the relevant requirements of the preceding paragraphs.

Attachment 2

# American Association For Laboratory Accreditation

ORGANIZATION 1989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Assessors
Approved by the Board

4/19/89

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THE AMERICAN INSTITUTE OF ARCHITECTS

APR 28 1989

April 20, 1989

The Honorable Doug Walgren
U.S. House of Representatives
Washington, D.C. 20515-3818

Dear Representative Walgren:

As President of The American Institute of Architects (AIA), I urge you to support continued funding of the Center for Building Technology within the National Institute of Standards and Technology for fiscal year 1990. The AIA is the professional organization for registered architects with over 56,000 members. This year we celebrate our 132nd anniversary.

Continued funding of the Center for Building Technology is very important from a scientific perspective, but also from a professional and economic perspective. The Center has undertaken irreplaceable research into a wide range of areas of particular interest to the architectural profession. Projects such as indoor air quality, building energy conservation, building seismic and structural safety, and fire safety are all directly related to our profession. However, the results of the research will also protect the interest of the general public and its need for safe and efficient buildings.

In the area of building technology research the United States has, as in many other areas, lost its competitive advantage over foreign countries. We believe that the only way to regain that advantage is for the Federal government to continue supporting research in the building technology area and especially the research undertaken by the Center for Building Technology. We therefore support appropriations for FY1990 of $10 million which would restore the funding to its FY1986 level. We appreciate your support in this matter.

Sincerely,

Benjamin E. Brewer Jr.

Benjamin E. Brewer Jr., FAIA
President

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NATIONAL ROOFING CONTRACTORS ASSOCIATION

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g.T.

April 21, 1989

The Honorable Doug Walgren
Chairman, Subcommittee on
Science, Research and Technology
Suite 2321, House of Representatives
Washington, D.C. 20515

Dear Mr. Walgren:

We understand that the President's budget request includes a substantial reduction in funding for the National Institute of Standards and Technology's Center for Building Technology.

The Center is an unqualified success story, and we implore you not only to maintain funding at current levels, but to consider appropriating badly needed funds for new research programs.

At this time, the Center is the only facility of its kind in the country, and as such is uniquely capable of conducting research programs that our industry badly needs. Many of the issues the Center deals with are of serious national concern, and the research they are conducting, and propose to conduct, simply won't be done elsewhere. Consider, for example, the Center's work in energy loss in buildings. It has helped to establish the proper performance characteristics of insulation, and has contributed directly to national energy savings. And the work is just not being done elsewhere.

Consider also the Center's excellent studies on fire control. Again, these have resulted in real savings to U.S. business, and again, they are not being done elsewhere.

In addition, many of the Center's ongoing projects would need to be suspended under the proposed budget cuts--at a time when the Center should be doing even more work. These projects include studying the quality of interior air, the opportunities for computer integration in building design and construction, and work on substitutes for chlorofluorocarbons. These are not "blue sky" research projects, but rather represent work that has direct and immediate benefit to American industry.

In our own industry, the Center has been instrumental in examining new materials, developing appropriate performance criteria, and interacting with foreign manufacturers and applicators.

More than any of this, though, the Center has demonstrated a remarkable willingness to cooperate with the private sector in its work. We have co-sponsored conferences and Symposia, we have co-sponsored a researcher, and we have worked together to identify and develop research programs. The net result for us has been a better industry, and it would be a shame to sacrifice so much progress for relatively insignificant short-term savings.

We stand ready to provide you with more information on any of these matters, and I'd be more than happy to answer any questions you many have.

Respectfully,

William A Good

William A. Good, CAE
Executive Vice President

WAG/df

# Report to the Congress

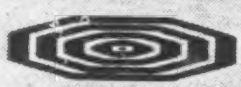
from

The Secretary of Commerce

on

# The National Technical Information Service: Fees and Declining Sales

Required by
PL 100-519



January 1989

# National Technical Information Service

# (NTIS)

## Report on Fees and Declining Sales

### I. Introduction

This *Report on Fees and Declining Sales* is in response to the requirements of section 212(f)(2) of the National Institute of Standards and Technology Authorization Act for FY 1989 (PL 100-519):

> "...the Secretary of Commerce shall submit to Congress a report on the current fee structure of the Service, including an explanation of the basis for the fees, taking into consideration all applicable costs, and the adequacy of the fees, along with reasons for the declining sales at the Service of scientific, technical, and engineering publications. Such report shall explain any actions planned or taken to increase such sales at reasonable fees."

The National Technical Information Service (NTIS) is the central source for the public sale of technical reports, computer software, and data files, as well as the leasing of intellectual properties generated by and for the U.S. Government. This function is intended primarily to improve the efficiency and effectiveness of the U.S. research and development enterprise and help increase productivity and innovation in the United States.

NTIS sells its technical information products and services under the provisions of Title 15 of the U.S. Code (1151-7). The law established the NTIS clearinghouse for scientific, technical and engineering information within the Department of Commerce and directed that it be self-supporting.

### II. Reasons for Declining Sales at NTIS

For many years, NTIS has occupied a specialized niche in the information industry, providing business and the general public with access to information on government sponsored scientific and technical research. The primary NTIS product has traditionally been a paper or microfiche copy of a technical report describing research results. During the past decade,

however, unit sales of these technical reports, whether in paper form or microfiche, have been cut in half.

A major factor contributing to this decline is an information explosion and the emergence of a major new industry, one dedicated to acquiring, producing, marketing and disseminating information. According to *Hotline*, the publication of the Newsletter Association:

> "Information is no longer a scarce commodity. Newsletter publishers have lost their franchise on specialized information. Now there is more competition from more places than ever before. Both the quantity and quality of competitive information is increasing. Magazines, newspapers, on-line databases, free literature supplied by businesses as a PR tool, etc. Result: An over supply of data (much of it low priced), saturated markets, and a decline in the perceived value of information."

This information explosion has given researchers many more information alternatives to the government sponsored technical report, and sales of NTIS technical reports have been hurt by the competition from this ever-growing list of information alternatives.

The technology with which users sort through all these new alternatives has also had its effect on NTIS sales. The last ten years have seen a significant migration away from paper-based bibliographic products toward greater use of online databases. This preference for online searching has resulted in continuing growth in NTIS' online revenues; it has also caused substantial decreases in the sale of NTIS' traditional paper bibliographic products: *Government Reports Announcements and Index, Abstract Newsletters*, and *Published Searches*. But the transition to online searching affects more than paper bibliographic products; it affects the sale of technical reports as well:

- With online searching, users can more easily and precisely identify the technical reports they need. With greater ease and precision comes increased selectivity: reports that once were bought because they "might be useful" are weeded out during the search process and are not purchased.

- Information end-users are more dependent on an intermediary, e.g., librarian, who devises and executes the search but who may also be more cost conscious and may purchase fewer of the reports identified.

- With fewer paper bibliographic products available for browsing or scanning as current awareness tools, end-use researchers order fewer technical reports.

- Growth in the online industry has been accompanied by development of a large number of databases more narrowly focused than that of NTIS. The increased cost associated with all online searching limits the number of databases likely to be accessed. As a result, many searchers find the more specialized databases more attractive, and the technical reports listed in the NTIS Bibliographic Database are not identified or purchased.

While the number of information alternatives, including online databases, has been growing, most NTIS customers report that their information budgets have not kept pace with this growth. As a general rule, customers are dealing with this situation by buying fewer paper and microfiche information products from all information providers, whether a government-subsidized operation such as the Defense Technical Information Center, a private sector operation such as the Chemical Abstracts Service, or NTIS.

At NTIS, paper and microfiche technical report sales generate about 50% of all revenues. The decline in unit sales for these products has forced NTIS to raise prices in order to cover the costs of its operation. Over the past decade, the price of the average paper technical report sold by NTIS has increased by approximately 180%. This is about in line with the rest of the information industry where, according to a recent survey conducted by the *Library Journal*, the price of the average scientific/technical journal has increased by approximately 200% over the last ten years.

In summary, the past decade has seen a decline in unit sales of paper and microfiche products for NTIS and most other information suppliers. Explosive growth in the number of information alternatives and continued user migration toward online services have been the major causes of this

decline. Price has been a factor, particularly as information budgets have failed to keep pace with the growing array of information offerings, but NTIS price increases have been no greater than those of other information suppliers.

## III. Basis for Fees and Costs

NTIS' legislation authorizes it to make the results of technological research and development readily available to industry, business and the general public. This legislation also requires that NTIS establish a schedule of reasonable fees for its products and services that enable the agency to be self-sustaining or self-liquidating. To provide an orderly way of satisfying both of these requirements, the Director of NTIS established a Pricing Committee with a charter directing it to "review, on a continuing basis, the prices of all NTIS products and services, and based on this review, make pricing recommendations consistent with the agency goals to the Executive Steering Committee." Each Spring, when the Pricing Committee begins its deliberations, it is faced with the difficult task of balancing two conflicting charges: ensuring that the results of federally-funded research and development receive the broadest possible dissemination while at the same time, generating sufficient revenue to offset operational costs.

In general, NTIS prices each product or service to recover the variable costs that are incurred to produce it, in addition to the fixed costs that must be allocated to it. Each product's price is based on such variable costs as printing, postage and other factors that vary with the individual product, and a proportional share of distributable and overhead costs. The *1989 NTIS Products and Services Catalog* lists the prices which NTIS charges for its products and services (see Attachment).

The NTIS financial plan provides the foundation for all pricing decisions. Prior to the beginning of the fiscal year, NTIS product managers forecast unit sales for the coming year. These are based on historical data, current trends and promotional efforts planned. The NTIS Budget Office then forecasts revenue by multiplying the projected unit sales by current prices. At the same time, individual program offices project operating costs for the coming year based on the unit sales forecast. Before aggregating these forecasts into a cost plan, the NTIS Budget Office calculates the effect of

such additional factors as increases in pay scales, postal rates, printing costs and computer charges.

The Pricing Committee compares the cost and revenue plans and evaluates the alternatives it might use to reach a break-even point, keeping in mind product characteristics, market conditions and industry trends. In its analysis, the Committee considers the impact of each alternative on the NTIS mission to disseminate the results of government research to a broad audience. Strategies in the past have included raising prices on selected products, instituting cost cutting measures, and delaying projects.

After completing its deliberations, the Pricing Committee prepares a report for NTIS executive management containing its recommendations together with an explanation of its rationale in terms of:

- Sales projections
- Expected cost increases/decreases
- Inflation forecasts
- Industry trends
- Mission implications.

Final adjustments are made in the recommendations, then NTIS announces a new pricing schedule for the next calendar year.

## IV. Steps to Increase Sales

Cost increases for federal salaries, postage and other elements over which NTIS has no control will continue to have a major impact on the prices the agency charges for its products and services. However, economies of scale resulting from selling more information products will enable NTIS to keep these increases to a minimum. NTIS is already pursuing the following activities to achieve these increased sales:

A. New Acquisition Strategy

NTIS' new acquisition strategy calls for the following:

- Enhancing the quality of the NTIS collection through increased interaction with federal information sources.

  This involves (a) preparing a new manual that promotes NTIS services for federal agencies that are current or potential contributors to the collection, (b) expanding our information sources liaison network, and (c) working with other federal information collectors such as GPO and the National Audio Visual Center for joint announcement of products.

- Increasing outreach to our user community to determine their information requirements.

  Part of this effort will include analyzing "best seller" lists to see what kinds of information attract the largest audiences and soliciting agencies for material similar to the best sellers.

- Expanding coverage of Japanese and other foreign scientific and technical (S&T) literature.

  NTIS is negotiating with the Japanese database producers trade association (INFOSTA) and the European Community (EC) to provide English-language access to Japanese "grey" literature and to provide documents cited in the EC's multinational technical database, SIGLE, available in the U.S.

B. Improvements to current products

- NTIS is constantly looking at ways to improve current products. An example is the change being made to the *Foreign Technology Abstract Newsletter*.

  The existing *Foreign Technology Abstract Newsletter* has been expanded to include articles based on reports submitted by science and technology counselors stationed at U.S .embassies, science officers of other U.S. Government agencies with overseas

offices, and various experts visiting foreign S&T organizations on the behalf of government agencies.

C Development of New Products

- New Technology

NTIS is exploring opportunities to take advantage of technological advances to offer new or improved products and services to its customers. The most significant are discussed below:

-- Computer-to-computer dissemination

The increasing sophistication of users of computer-readable products indicates that expanding NTIS' services to include computer-to-computer dissemination would be a welcome addition to our product line. This service would be more convenient to users and would give them faster turn-around for time-sensitive material. An added benefit for NTIS would be less manual handling of orders.

-- Diskette Products

For many users, desk-top computers have become the preferred means of searching for information. Products such as weekly *Abstract Newsletters*, indexes for *Selected Research in Microfiche (SRIM)* and *Published Searches* lend themselves to the diskette medium, especially when packaged with built-in search software or formatted for specific commercial software.

-- CD-ROM Products

As a part of the outreach efforts of the NTIS Federal Computer Products Center, NTIS is actively involved with the federal producers of electronically stored databases. This Center disseminates federal numeric, statistical, and textual databases to the private sector. In the past, NTIS has distributed these databases on magnetic tape or diskettes.

Recently, NTIS has entered into joint ventures with commercial vendors to make its bibliographic database and other federal databases available on CD-ROM.

- Customized products

  -- Alert services

  In a joint effort with university research and development centers, NTIS is developing a new promotional product designed to provide business and industry with specialized alert bulletins in various high technology areas. The alert, which will highlight recently acquired NTIS technical reports selected by the university personnel, will be sent directly to scientists and engineers working in the specific discipline. The purpose of the alert, with its emphasis on reports that have been reviewed by qualified specialists, is to make a new audience aware of NTIS' products.

- Marketing

  In order to promote NTIS products and services to U.S. businesses and academic institutions, NTIS conducts an active marketing program. During FY 1988, NTIS ran 15 major campaigns with 41 mailings, totalling some 700,000 promotional pieces highlighting NTIS information products and services. NTIS also exhibited at 13 conferences and trade shows. An even more aggressive program is planned for 1989.

- Contracting out of the Promotions Division

  NTIS is evaluating and preparing work statements to contract out the functions of the Promotion Division, as specifically authorized by Public Law 100-519. By contracting out this activity to one or more advertising, promotion and direct marketing firms, NTIS anticipates that new and innovative promotional techniques will increase the sales of the various information products and services of NTIS.

D. Better Customer Relations

- Business and Industry Liaison

Most NTIS customers are business and industry organizations. NTIS has begun to work closely with groups that represent the information needs of this sector such as the Special Libraries Association (SLA) and the Industrial Technical Information Managers Group (ITIMG). This helps us to gain a better understanding of specific needs for federal information as well as ways that we can improve service to their member companies.

The SLA and its over 12,000 members are concerned with programs whereby public documents and government information are easily accessible and readily available to the special library community.

The ITIMG, which is composed of information managers from some of America's largest corporations, seeks to improve the flow of technical information resources to end-users within their companies.

- Database Training

A new training program for searching the NTIS Bibliographic Database online is designed to instruct users in methods of better information retrieval. Training workshops provide a forum to describe NTIS and its products and services, and to increase the visibility of the database to the user community. Sessions include a general overview of NTIS, specifics about the NTIS databases and usually a "hands-on" activity which allows users to access NTIS databases directly from computer terminals.

- Telephone Improvement Program

NTIS recently embarked on a program to improve our telephone system, in order to alleviate the frustration that some potential customers experienced when trying to obtain

information or place an order. NTIS installed an automated call distribution (ACD) system in Sales and Customer Services in 1988. The ACD, which evenly distributes calls to the next available agent, also provides data that enable NTIS to manage these resources more efficiently.

- Customer Feedback

  In order to gain an understanding of customer needs, NTIS regularly obtains comments from its users to determine their buying patterns and perceptions of NTIS' products and services. For example, in 1988, NTIS queried customers who use our Deposit Account system extensively to learn which factors, e.g., price, currency of information, order turnaround time, most influenced their buying decisions. A formal survey queried subscribers to NTIS *Abstract Newsletters* to investigate their perceptions of this product group.

E. Joint Ventures Program

NTIS began actively pursuing joint ventures in 1988, as a means of developing certain new and improved products and services. Emphasis has been placed on information products that can best be developed through the combined resources of NTIS and one or more private sector organizations. We have defined joint ventures as activities in which NTIS and a private sector partner work together to achieve a common objective, whose accomplishment involves the investment of resources by both partners with a formal agreement for sharing of risks and benefits associated with the venture.

Six joint ventures were initiated in 1988:

- Sweets, a subsidiary of McGraw Hill, Inc. publishes an 18 volume catalog that provides comprehensive product specification information to the nation's architectural, building design and construction firms. In this joint venture, NTIS will serve as (a) the federal buyer of the catalog service on behalf of all other agencies, and (b) the vehicle for transferring funds between the firm and agencies wishing to use its catalog system.

- Javelin Associates, Inc. will select education and training related items from the NTIS Bibliographic Database and highlight them in a quarterly paperback directory. These directories will make a valuable contribution to our effort to generate increased use of federally-developed training materials to enhance worker skills, and thereby improve the nation's productivity and competitiveness.

- BRS Information Technologies, a major database vendor, is marketing a new package to the academic community, one that will enable a university to mount BRS' search and retrieval software plus a group of databases (including the NTIS Bibliographic Database) on the university's computer for unlimited use by faculty and students.

- National Information Services Corp., a small start-up business, has acquired the Selected Water Resources Abstracts Database from NTIS and is promoting and marketing a CD-ROM version of this product.

- Xerox Palo Alto Research Center is sending technical reports produced by their scientists to NTIS which will announce and sell them to the public.

- The Brick Institute of America will identify and review technical reports about brick and masonry and produce a new column in their newsletter, journal and magazine alerting scientists and engineers involved in the manufacturing process as well as in research and development of high quality documents recently acquired by NTIS. The Institute is especially interested in foreign information because some technology used abroad is more advanced than in the United States.

A number of other joint venture possibilities are under discussion.

## V. Summary

The past decade has seen an information explosion and intense competition for the information dollar. Many organizations are relying on online database searching instead of the traditional printed announcement

products, such as journals and newsletters, to search for technical report literature. Furthermore, budgets for information acquisition have not increased at the same rate as either the price of information or the growing number of information offerings. These factors have changed the information industry as well as NTIS.

NTIS' enabling legislation requires NTIS to establish a schedule of reasonable fees for its products and services that enable the agency to be self-sustaining. On an annual basis, the NTIS Pricing Committee compares the cost and revenue for its products and services and examines the alternatives it might use to reach a break-even point. This analysis is the basis for pricing recommendations which are presented to the Director. After final cost and pricing decisions are made by the Director, NTIS announces a new pricing schedule for the coming year.

NTIS is pursuing several activities to increase sales of its products and services. These activities include:

- A new acquisition strategy to increase the quality and quantity of the NTIS collection through increased interaction with U.S. and foreign government information sources.

- Improvements to current products, development of new products (taking advantage of technological advances such as computer-to-computer dissemination and CD-ROM), and new and innovative promotional techniques.

- Better customer relations by working more closely with business and industry groups, increased database training, improvements to the telephone access systems, and obtaining better customer feedback.

- Actively pursuing joint ventures as a means of developing new and improved products and services for information users that can best be developed through the combined resources of NTIS and one or more private sector organizations.

ADVANCE COPY

United States General Accounting Office

GAO

Report to Congressional Requesters

June 1989

STANDARDS AND TECHNOLOGY

# Impact of Fee Increases on Measurement Services

GAO/RCED-89-135

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-235260

The Honorable Robert A. Roe
Chairman, Committee on Science,
Space and Technology
House of Representatives

The Honorable Robert S. Walker
Ranking Minority Member, Committee on
Science, Space and Technology
House of Representatives

On October 20, 1988, you requested that we analyze the potential impact of proposed fee increases on sales of calibration services and standard reference materials provided by the National Institute of Standards and Technology (NIST)--formerly the National Bureau of Standards--in the Department of Commerce. As agreed with your office, to assess the impact of the fee increases, we analyzed the changes in prices and corresponding changes in service levels (demand) for calibration services and standard reference materials between fiscal years 1979 and 1988. We also evaluated the justification for proposed fiscal year 1989 fee increases that NIST submitted to your Committee on September 19, 1988.

## RESULTS IN BRIEF

Because data were not readily available to measure the impact of various factors that affect demand, we could not determine how much impact, if any, price changes alone had on the demand for NIST calibration services and standard reference materials between fiscal years 1979 and 1988. Our analysis suggested, however, that demand was affected by factors other than price changes, such as the market conditions for NIST customers' products and services.

In justifying its proposed fiscal year 1989 fee increases, NIST did not fully explain the nature or the likely impact of the fee increases on the demand for measurement services, which we believe would have helped the Committee evaluate the appropriateness of the increases.

## BACKGROUND

Calibration services and standard reference materials assist businesses and research laboratories in precisely measuring the physical and chemical properties of materials. Calibration services generally include checking, adjusting, or characterizing particular instruments, devices, or sets of standards on a one-time-per-request basis. The cost for these services in fiscal year 1988 averaged $471 per calibration and ranged from less than $100 to calibrate a laboratory thermometer to over $50,000 for special tests of large microwave antenna systems. Standard reference materials are certified for certain chemical properties, such as the composition of steel, or physical properties, such as the thickness or weight of coatings. They can be used for calibrating an instrument, assessing a measurement method, or assigning values to materials. In fiscal year 1988 the cost for standard reference materials averaged $144 per unit and, according to a NIST official, ranged from $39 for five microcopy test charts to $3,536 for an optical microscope linewidth-measurement standard used in manufacturing integrated circuits.

### Fees for Calibration Services

NIST's customers are charged for calibration services based on the number of tests performed on an item. In December 1987 NIST increased the price of calibration services, which had been based on its technical division's costs to perform these services and an operations surcharge of about 13 percent to cover administrative office expenses, by adding a "development surcharge" to support the development of new and improved calibration services. NIST set the development surcharge at 8 percent of the technical division's costs to perform calibration services for fiscal year 1988 and plans to increase it by 8 percent each year until the surcharge is about 40 percent of the technical division's costs in fiscal year 1992.

### Fees for Standard Reference Materials

The price of a standard reference material is based on (1) the direct cost of producing and certifying it; (2) an operations surcharge to cover packaging, inventory, sales, and distribution costs; (3) fees to cover such costs as obsolescence and differences between direct production costs and fair market value; and (4) a development surcharge that was introduced in fiscal year 1983 for the development of new and improved standard reference materials. In

December 1987 NIST increased the development surcharge from 15 percent to 20 percent of the direct cost of producing a standard reference material, which on average represented only about 39 percent of NIST's total price. (The surcharge was $7.80 on average for standard reference materials costing $100.) NIST plans to increase the development surcharge by 5 percent annually until it is about 40 percent of the direct production cost in fiscal year 1992.

Requirement that NIST Justify Further Fee Increases

Section 5114 of the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418) requires that NIST justify in writing to the Senate Committee on Commerce, Science and Transportation and the House Committee on Science, Space and Technology all policy changes regarding fees for standard reference materials and calibration services, including a description of the anticipated impact of any proposed changes in demand for and revenues from these services.

## CHANGES IN FACTORS OTHER THAN PRICE CAN AFFECT DEMAND FOR NIST MEASUREMENT SERVICES

In analyzing the changes in real average prices and service levels for standard reference materials and calibration services between fiscal years 1979 and 1988, we found that factors other than price also affected the demand for these services.[1] According to NIST officials, price increases generally have affected the demand for NIST measurement services less than other factors, such as general economic conditions, market conditions for products or services that NIST's customers provide, and the availability and price of alternative services. The NIST officials noted that measurement service costs are negligible in comparison with the costs of equipping and operating a laboratory that uses the services. They said customer feedback has indicated that most customers (1) are willing to pay higher fees for new and improved services and (2) can adjust their budgets to the higher prices if they are aware of the price increases ahead of time. The NIST officials also observed that customers may be able to pass on price increases to their own customers or alternatively, depending on the degree of accuracy required, customers may reduce costs by using less expensive measurement services offered by private

[1]We analyzed NIST's average price for services in real dollars to account for inflation.

industry or increase the time between obtaining measurement services from NIST.

Calibration Services

We found that the number of calibration tests performed increased in each year between fiscal years 1984 and 1988, even though the real average price per test also increased in each year except fiscal year 1984, indicating that changes in factors other than price also affected the demand for calibration services. For example, the largest price change, a 17-percent increase in fiscal year 1986, corresponded with a .2-percent increase in the number of tests performed. In fiscal year 1988, despite a real average price increase of 6 percent, the number of tests performed increased by 3 percent. (See app. I for a year-by-year analysis.)

The Chief of NIST's Office of Physical Measurement Services said that the economic state of the defense and aerospace industries has been and is likely to continue to be the most important market force affecting the demand for calibration services. This is because defense procurement contracts that specify a high degree of measurement precision comprise a significant portion of the demand for calibration services.

Standard Reference Materials

We found that price changes had some effect on the demand for standard reference materials between fiscal years 1979 and 1988. In particular, the largest price change, an increase of 23 percent in fiscal year 1983, corresponded with the largest change in demand, a decrease of 16 percent. However, factors other than price also affected the demand for standard reference materials. Both the real average price and the number of units sold increased in fiscal years 1985 and 1987, indicating that other factors overshadowed price changes. The magnitude of the fluctuations in demand in other years also reflected the effect of factors other than price. (See app. I for a year-by-year analysis.)

The Chief of the Office of Standard Reference Materials told us that several factors can affect the demand for particular standard reference materials. He said that it is not uncommon for NIST to be out of stock or have a backlog of orders for a given material. He cited, as an example, that the optical microscope linewidth-measurement standard has a waiting list of up to 2 years because (1) it is critical for

producing integrated circuits, (2) NIST is the only producer of this material, and (3) NIST requires 2 weeks to produce each one. For the human serum standard reference material, although prices increased (28 percent in fiscal year 1987 and 9 percent in fiscal year 1988), sales increased even more (by 45 percent and 19 percent, respectively) because of increased quality consciousness in the clinical industry. Alternatively, he mentioned that sales of microscopy test charts dropped (from 2,335 units in fiscal year 1986 to 695 in fiscal year 1987) in large part because a major customer decided to produce its own.

NIST's ANALYSIS AND JUSTIFICATION TO THE COMMITTEE FOR FEE INCREASES

In a letter dated September 19, 1988, the Director of NIST notified the Senate Committee on Commerce, Science and Transportation and the House Committee on Science, Space and Technology of NIST's intent to increase the development surcharge fees in fiscal year 1989. (See app. II.) The director concluded that the fiscal year 1988 development surcharge increases had "no deleterious impact" on measurement services income and that small business demand increased by 21 percent for calibration services and declined by 1 percent for standard reference materials. Data were enclosed for both programs showing current and projected revenues from the proposed fee increases; the sales history for fiscal years 1978 through 1988, including the service levels, gross income, and average price per item; and a comparison of income collected in various categories of customers in fiscal years 1987 and 1988.

We believe NIST could have improved its analysis and presentation of information on the nature and possible impacts of the fee increases to assist the Committees in their deliberations by (1) clearly indicating that the development surcharges would be applied to only a portion of the total sales price, (2) analyzing annual changes in average prices and income using real dollars to account for inflation, (3) controlling for or explaining the likely effects of other factors on customer demand, and (4) more clearly showing the impact of price changes on customer demand. In addition, we noted that NIST could have improved its analysis of calibration services by comparing income with the number of calibrations, rather than the number of items calibrated, because NIST charges its customers on the basis of tests performed.

After we discussed our findings and observations with your office on January 30, 1989, you sent a letter to the acting Director of NIST on February 8, 1989, approving the proposed 1989 fee increases but requesting that NIST meet with us to consider the results of our work and more clearly present data justifying any further increases. In a meeting with our staff on March 29, 1989, NIST officials agreed with our observations about how they could more clearly present information justifying future increases and added that our report would be helpful in preparing future justifications.

## SCOPE AND METHODOLOGY

NIST officials provided us with information and statistics on the prices, service levels, and program income for calibration services and standard reference materials from fiscal years 1978 through 1988. We analyzed these data to determine the relationship between price changes and changes in service levels. To compare prices over time, we adjusted the average price for inflation by calculating a real average price by (1) adjusting yearly income to its 1982 equivalent by dividing it by the producer price index for intermediate materials, supplies, and components and (2) dividing the adjusted income by the number of calibration tests performed or units of standard reference materials sold, as appropriate. We also reviewed past, present, and planned pricing policies for these services but did not survey NIST's customers to obtain their views on the impact of these pricing policies.

We conducted our review in January and February 1989. We discussed the report's contents with responsible agency officials and incorporated their views where appropriate. However, as requested by your office, we did not obtain formal agency comments on a draft of this report.

- - - -

As agreed with your office, we are sending copies of this report to the Secretary of Commerce and other interested parties. Copies also will be made available to others upon request. Major contributors to this report are listed in appendix III.

John M. Ols, Jr.
Director, Housing and Community
Development Issues

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ABBREVIATIONS

| | |
|---|---|
| GAO | General Accounting Office |
| NIST | National Institute of Standards and Technology |

## NIST MEASUREMENT SERVICES: SERVICE LEVELS AND INCOME FOR FISCAL YEARS 1978-1988

Table I.1: Service Levels and Income for Calibration Services

| Fiscal year | Tests performed[a] | Items calibrated | Total income (millions) |
|---|---|---|---|
| 1978 | N/A | 6,191 | $1.8 |
| 1979 | N/A | 6,924 | 2.1 |
| 1980 | N/A | 6,887 | 2.3 |
| 1981 | N/A | 7,506 | 2.5 |
| 1982 | N/A | 6,828 | 3.1 |
| 1983 | 12,209 | 8,087 | 3.6 |
| 1984 | 12,672 | 6,880 | 3.8 |
| 1985 | 12,737 | 5,779 | 4.1 |
| 1986 | 12,767 | 5,023 | 4.7 |
| 1987 | 13,059 | 5,611 | 5.5 |
| 1988 | 13,425 | 5,902 | 6.3 |

[a]NIST did not maintain records on the number of tests performed prior to fiscal year 1983.

Table I.2: Service Levels and Income for Standard Reference Materials

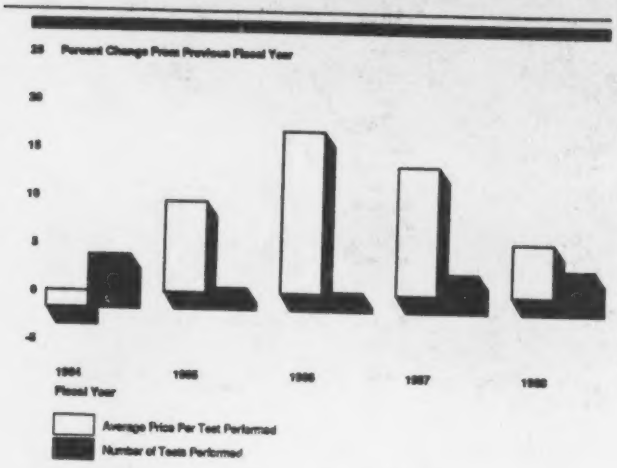
| Fiscal year | Units sold | Total income (millions) |
|---|---|---|
| 1978 | 37,387 | $2.5 |
| 1979 | 38,139 | 2.6 |
| 1980 | 40,847 | 3.0 |
| 1981 | 40,304 | 3.5 |
| 1982 | 39,523 | 3.8 |
| 1983 | 33,199 | 4.0 |
| 1984 | 36,674 | 4.4 |
| 1985 | 40,518 | 5.2 |
| 1986 | 40,149 | 5.2 |
| 1987 | 40,848 | 5.6 |
| 1988 | 44,484 | 6.4 |



98-198 O - 89 - 32

APPENDIX I

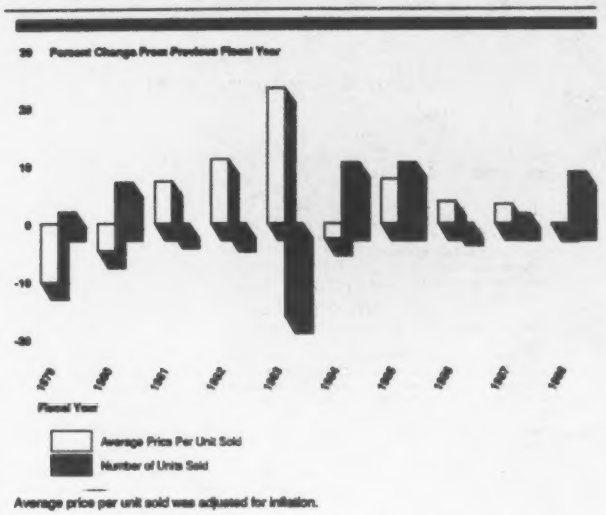
Figure I.1: Changes in Real Average Price Per Test and Number of Tests Performed for Calibration Services




Average price per unit was adjusted for inflation.

Source: Prepared by GAO from NIST data.

Figure I.2: Changes in Real Average Price Per Unit and Number of Units Sold for Standard Reference Materials




Average price per unit sold was adjusted for inflation.

Source: Prepared by GAO from NIST data.

APPENDIX II

## NIST's JUSTIFICATION FOR ITS FISCAL YEAR 1989 DEVELOPMENT SURCHARGE FEE INCREASES

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards

SEP 1 9 1988

Honorable Robert Roe
Chairman, Committee on Science,
Space and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

As I notified you last year, NIST increased its fees charged for standard reference materials and calibration services, effective December 6, 1987. This was part of our five-year plan to increase fees incrementally to a final surcharge level of approximately 40% for each service. The funds collected from the surcharges are used to offset costs associated with developing new and/or improved standard reference materials and calibrations needed by industry at large.

Improved measurement methods and standards are needed for measurement quality assurance in traditional science and technology areas, and at the same time, industry and the science communities need new measurement methods and standards for new emerging technologies. The increases for this past year have allowed NIST to further serve industry as a whole without adversely affecting individual customers, including small business. The next incremental increase in fees would allow NIST to further expand its efforts to improve its existing measurement services and develop new services.

In response to your Committee instructions dated November 17, 1987, NIST has monitored the effect of the 1988 fee increases on the demand for services and the impact on small business, non-profit organizations and other organizations with limited financial means. The data we have collected to date indicates no deleterious impact on income as a result of these fee increases and has resulted in a drop of only 1% in the income level from small business for reference materials and an increase of 21% in the level of calibration services provided to this same class of customers. I am enclosing several graphs displaying the sales history and income levels for both standard reference materials and calibrations.

Based on this review we intend to implement the second incremental increase to the fees at the beginning of fiscal year 1989. I am enclosing a chart showing current and projected revenues and surcharge rates from the increases.

APPENDIX II

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards

In accordance with Section 3114 of Public Law 100-418, the Omnibus Trade and Competitiveness Act of 1988, this letter is intended to notify you of our plans to implement this next incremental fee increase.

Sincerely,
Original Signed By
Ernest Ambler

Ernest Ambler
Director

Enclosures

cc: Manuel Lujan, Jr.
Ranking Minority Member

APPENDIX II

APPENDIX II

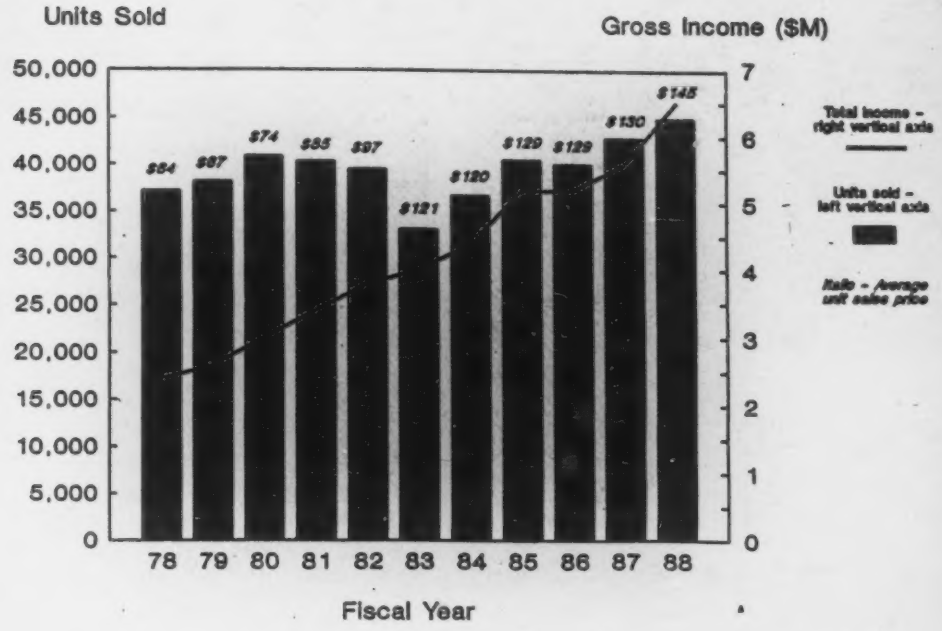
Current and Projected Revenues from Proposed Fee Increases

| | FY 87 | FY 88 | FY 89 | FY 90 | FY 91 | FY 92 |
|---|---|---|---|---|---|---|
| Calibrations | | | | | | |
| Technical service level: | ... | $3.5M | $6M | $6M | $6M | $6M |
| Development surcharge rate applied: | ... | 8% | 16% | 24% | 32% | 40% |
| Development funds from customer fees annually ($K): | ... | 250 A/ | 960 | 1,440 | 1,920 | 2,400 |
| Change margin: | ... | +250 | +710 | +480 | +480 | +480 |
| SRM | | | | | | |
| Production costs: | $2.3M | $2.3M | $2.4M | $2.4M | $2.4M | $2.4M |
| Development surcharge rate applied: | 15% | 20% | 25% | 30% | 35% | 40% |
| Development funds from customer fees annually ($K): | 348 | 463 | 600 | 720 | 840 | 960 |
| Change margin: | ---- | +115 | +137 | +120 | +120 | +120 |
| Total combined cumulative | 348 | 713 | 1,560 | 2,160 | 2,760 | 3,360 |

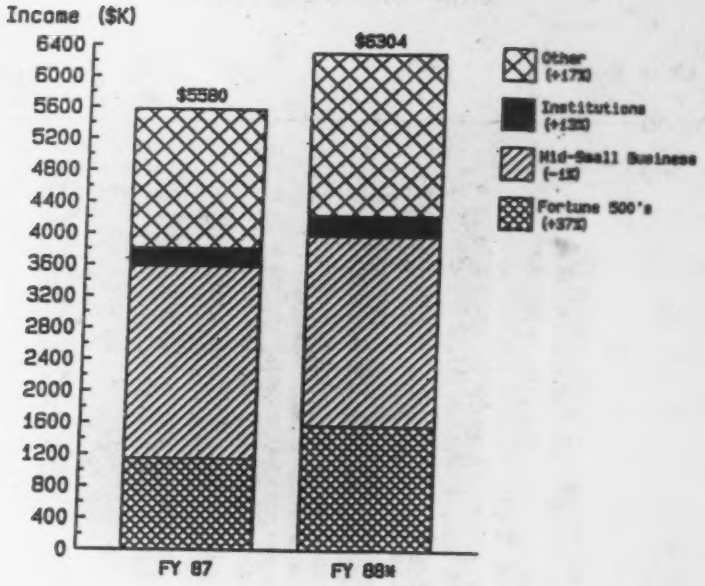
A/ Lapsed resulting from delayed implementation for fiscal year 1988.

APPENDIX II

## SRM SALES HISTORY



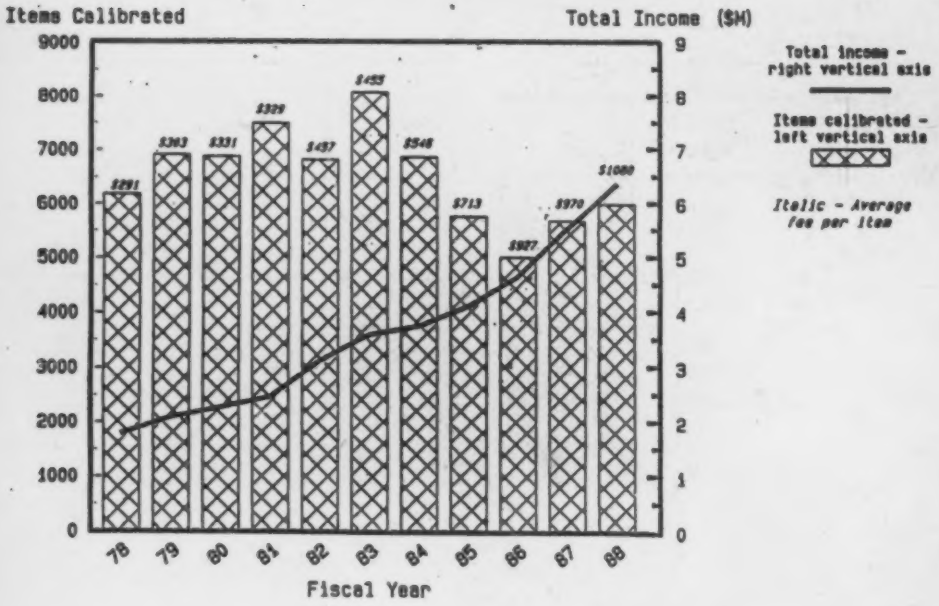
# COMPARISON OF SRM INCOME BY CUSTOMER CATEGORY



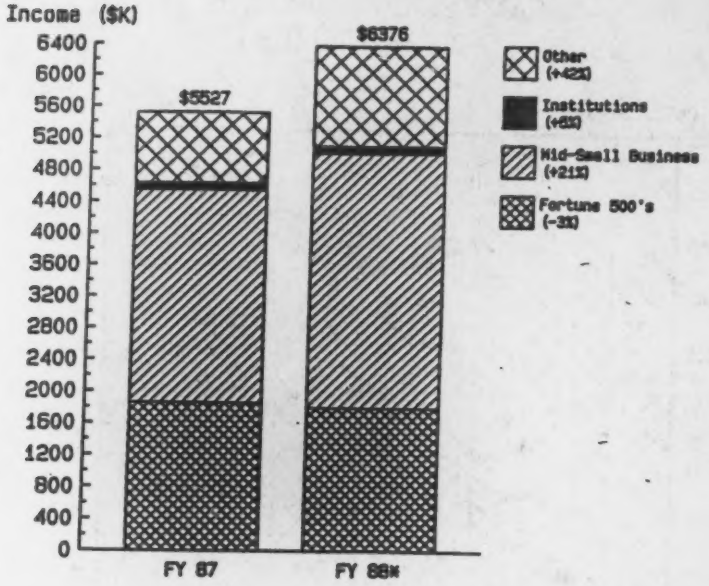

*Fourth Quarter Projected

APPENDIX II

# CALIBRATION SALES HISTORY
# ITEMS CALIBRATED



# COMPARISON OF CALIBRATION INCOME BY CUSTOMER CATEGORY




*Fourth Quarter Projected

## MAJOR CONTRIBUTORS TO THIS REPORT

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(005755)

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
U.S. DEPARTMENT OF COMMERCE

# REPORT ON

# DOMESTIC TECHNOLOGY TRANSFER ACCOMPLISHMENTS, TRENDS, AND PLANS SINCE 1986

Submitted to the:

House Committee on Science, Space, and Technology

Senate Committee on Commerce, Science, and Transportation

March 1989

## 1. Introduction

This report on domestic technology transfer accomplishments, trends, and plans, since 1986, is in response to Section 109 of the National Bureau of Standards Authorization Act for fiscal year 1989. The report also addresses Committee questions relating to the division of technology transfer activities between the Gaithersburg, Maryland, and Boulder, Colorado, sites of the National Institute of Standards and Technology (NIST), formerly the National Bureau of Standards.

## 2. NIST Policies and Actions Pursuant to Technology Transfer Act of 1986

The Technology Transfer Act and accompanying Executive Order are intended to ensure that Federal agencies and laboratories take an active role in broadening the U.S. technology base by moving knowledge from the research laboratory into the development of new products and processes. NIST has always viewed the effective transfer of its work to the private sector and to State and local governments as an essential part of its mission, and has perhaps the best track record of any federal laboratory when it comes to working cooperatively and sharing information with scientists and engineers from industry, academia, and government.

It is NIST's policy to encourage programs which provide opportunities for joint research and collaboration in keeping with its stated goal of strengthening and advancing the nation's science and technology and promoting their effective application for public benefit. Accordingly, the transfer of NIST technology and know-how is a responsibility of every professional staff member. Because the technical staff members are the primary agents for technology transfer, there is proportionate activity in the Gaithersburg, Maryland and Boulder, Colorado sites.

Pursuant to the Stevenson-Wydler Act, NIST established an Office of Research and Technology Applications in 1980 to improve industry's access to the Institute, its facilities, and programs, both in Gaithersburg and in Boulder. The Office works with NIST staff at both sites to coordinate the development of cooperative R&D programs with industry; to process invention disclosures; and to assist in the commercialization of relevant technology. The ORTA Office works effectively with staff and programs at both sites and there are no present indications that establishing a branch ORTA Office in Boulder is needed.

In January 1988, the Secretary of Commerce delegated authority to the NIST Director to enter into cooperative agreements pursuant to the Technology Transfer Act. The Director further delegated such authority to the Directors of the four NIST major operating units in March 1988. In September 1988, NIST issued policy and administrative guidelines pertaining to the Act, including model cooperative agreements to be used by staff in negotiating R&D partnerships with industry.

In July 1988, NIST conducted workshops on patents and on cooperative R&D agreements for its staff in Boulder, Colorado, to explain new policies and guidelines and to train the staff and technical managers in the use of the cooperative R&D agreements. The same workshops were conducted in February 1989 for staff at NIST's Gaithersburg, Maryland site.

3. NIST Technology Transfer Activities

NIST technology transfer activities can be grouped into three areas. Each is described below, and in Tables 1-4 with data that represent present levels of activity.

Cooperative R&D Programs and Partnerships - It should be emphasized that the most effective means of technology transfer is R&D partnering. The Technology Transfer Act has provided increased flexibility to laboratory directors in this regard. Dr. Roland Schmitt, President of Rensselaer Polytechnic Institute, and past Director of R&D for General Electric, recently highlighted the importance of R&D partnering as follows:

> "The problem is that when you start thinking of technology transfer as a separate process from R&D, you've already lost the game. The user and the performer of targeted R&D need to have established a relationship before there is anything to transfer. What you need is not technology transfer but technology teamwork."

Nowhere in government is this philosophy of R&D partnering better exhibited than in NIST's Research Associate Program, which has been operating since 1921. Through it, industrial scientists and engineers work at NIST for a limited period of time at their employer's expense. This year, there were 185 industrial researchers at the Institute doing collaborative work with their peers in NIST. About 35% of the research associates were from small businesses, and over the past several years there have been 41 research associates in the Automated Manufacturing Research Facility. This program is a cost efficient and effective way for NIST and industry to form partnerships on research projects of mutual interest. Industry benefits by gaining access to facilities and expertise it might not otherwise enjoy. NIST benefits by gaining high quality additional research talent at almost no cost while at the same time the NIST Staff obtains an important perspective on the plans and needs of its industrial partners. At present, all research associate agreements are written as Cooperative Research and Development Agreements within the meaning of the Technology Transfer Act to take full advantage of the flexibility provided to government and industry in negotiating intellectual property rights.

Most of the cooperative agreements are oriented to assisting industry in quickly adapting new technology in manufacturing, in industrial processes, and in developing the associated measurement means and methods for controlling the quality of resulting products. NIST research in emerging technologies like advanced materials, microelectronics, automation, biotechnology, and thin layer technologies, is driven by the need to develop measurement standards and methods that industry must have to properly understand and measure the properties and performance characteristics of materials and processes. Such standards and measurement methods are critical in applying new advances in materials, in manufacturing, and in industrial processes.

Similar to the Research Associate Program, NIST permits scientists and engineers from universities and other public and private organizations to spend time at the Institute as Guest Researchers pursuing individual research objectives within the scope of NIST's ongoing programs. This year, some 900 guest researchers, primarily from academia, took advantage of the program. It is an effective means of technology transfer to university programs that support business activities at the State and local level.

Measurement, Reference Data, and Standards Services - NIST transfers technology through measurement and reference data services which are offered to industry, academia, and government on a reimbursable basis. In the measurement services area, the Standard Reference Materials Program provides well-characterized materials or sample artifacts with special chemical or physical properties certified by NIST that are used in industrial materials production and analysis, environmental analysis, health measurements, and basic measurements in science and technology. Fiscal year 1988 was a record year for the sales and distribution of standard reference materials, with more than 44,000 units sold and total income of $6.4 million.

The NIST Calibration Services Program links the makers and users of precision instruments to national measurement standards as a means of assuring reliable and accurate measurements to satisfy a variety of process or production specifications. NIST currently provides more than 480 different calibrations, measurement assurance programs, and special tests in seven major measurement areas. This year, more than 13,000 tests were performed on over 5,900 standards and devices calibrated by NIST technical divisions, providing an income of $6.3 million. The Standard Reference Data Program provides evaluated data on the chemical and physical properties of materials that are vital to industry and the scientific community.

Information Dissemination - NIST disseminates information about its research and development activities through published research papers, speeches at conferences and workshops, promotional materials (including videotapes) describing NIST programs and specialized facilities, participation on voluntary standards committees, and hosting of conferences and workshops. These activities focus on supplying information about NIST programs to industry, academia, and government as a means of informing, transferring knowledge, and identifying opportunities for cooperative R&D. Typically, NIST hosts more than 100 technical conferences and 400 workshops annually which attract more than 12,000 attendees, providing exposure to the Institute's facilities, staff, and R&D projects. About 30% of the Institute's technical staff participate on voluntary standards committees of various private sector organizations. Here they work cooperatively with their peers from industry and government to write documentary standards covering products and services that are widely used in trade and industry. NIST staff annually prepare about 1,900 technical publications, make more than 1000 technical talks, and respond to more than 29,000 public inquiries.

4. Funding Devoted to Technology Transfer Activities

It is difficult to estimate accurately the amount of resources that go into technology transfer activities because such activities are an integral part of the Institute and its programs. The estimates provided below include funds allocated to the NIST Office of Research and Technology Applications; Measurement, Reference Data, and Standards Services Programs; and funds earmarked by the Congress for the Regional Centers for the Transfer of Manufacturing Technology, which will support the Centers through 1990. Not included in the estimate are resources involved in information dissemination activities at the staff level because there are no data to support reasonable estimates.

| | FY88 | FY89 |
|---|---|---|
| | (in thousands of dollars) | |
| Funding allocated for technology transfer activities..... | 12,436 | 15,038 |

5. NIST Patent and Licensing Activities

In the period between 1977 and 1986, NIST obtained about four patents a year on inventions coming from its technical units. The average annual royalty from licenses of NIST patents during the period was $15,500. In 1987 and 1988, NIST has averaged about 12 patents a year, a considerable increase over past years. Also, the number of invention disclosures almost doubled in the past two years; from 26 in 1987 to 42 in 1988. Similarly, royalties from licenses have increased from $25,000 in 1987 to almost $79,000 in 1988. Also, in keeping with the Technology Transfer Act provisions regarding shared royalties with inventors, NIST has distributed 15% of incoming royalties to affected inventors in 1987 and 1988.

While the numbers for royalties from inventions seem small, NIST nevertheless is among the top four Federal agencies in royalty payments. Also, the increases in NIST invention disclosures and patents in 1987 and 1988 are significant, and are due to a concerted effort by NIST to better manage and protect its intellectual property, and to a realization by staff scientists that they may be rewarded for patentable inventions that have commercial potential. In this respect, the Technology Transfer Act has been successful in getting agencies to pay more attention to "business-like" management of their intellectual property assets.

TABLE 1

INFORMATION EXCHANGE

| Activity | Number (Fiscal Year 1988) |
|---|---|
| Technical Publications | 1,904 |
| Technical Talks | 1,041 |
| Major Conferences at NIST | 93 |
| Conference Attendees | 11,907 |
| Workshops and Seminars | 440 |
| Public Inquiries | 28,670 |
| Publication Exchange Agreements | 302 |

TABLE 2

SERVICES

| Activity | Number (Fiscal Year 1988) | Value ($M) |
|---|---|---|
| Other Agency Contracts | 728 | 90.8 |
| Calibration Tests | 13,425 | 6.3 |
| Standard Reference Materials | 44,484 | 6.4 |
| Standard Reference Data | | |
| Number of Centers | 24 | |
| Pages of Data | 5,240 | |
| Laboratory Accreditation | | |
| Programs | 10 | 8.7 |
| Laboratories Accredited | 176 | |
| Accreditations in Process | 600 | |

TABLE 3

DOCUMENTARY STANDARDS

| Activity | Number (Fiscal Year 1988) |
|---|---|
| Organizational Involvements | 413 |
| Committee Memberships | 1,301 |
| Committees Chaired | 127 |
| Standards Information Queries | 4,400 |

TABLE 4

COLLABORATIONS WITH DOMESTIC ORGANIZATIONS

| Type | Percentage of Total* |
|---|---|
| Industrial Companies | 46 |
| Universities | 26 |
| Federal Agencies | 13 |
| National Laboratories, Trade Associations, and Professional Societies | 11 |
| Government-Owned, Contractor-Operated Laboratories | 4 |

* 1,525 Total in Fiscal Year 1987

National U.S.-Arab Chamber of Commerce

1625 Eye Street, N.W.
Suite 902
Washington, D.C. 20006
U.S.A.

Telephone: (202) 331-8010
Fax: (202) 331-8297
Telex: 9102507574
Answerback
NATL US ARAB UQ

June 15, 1989

Honorable Doug Walgren
Chairman
Subcommittee on Science
Research and Technology
2319 Rayburn
Washington, D.C. 20515

Dear Mr. Chairman:

On behalf of the American Businessmen of the Gulf Arab States, the National U.S.-Arab Chamber has been working with the National Association of Manufacturers and the U.S. Chamber of Commerce to establish an American presence at the Saudi Arabia Standards Organization (SASO) proceedings.

Last year, Congressman Merwyn Dymally sponsored authorizing legislation to establish a pilot program to support an American standards expert. Commerce Secretary Verity asked the American/Saudi Roundtable to raise funds from the private sector to send an American expert to work with SASO in Riyadh. The Roundtable has raised $180,000 to date and expects to have an American expert in Riyadh by the end of summer.

While the U.S. continues to look for ways to support an American standards expert in Riyadh, the Saudis have relaxed enforcement of standards they have already adopted because of the uproar about storing and shipping penalties for incompatible goods. It is only a matter of time before the U.S. truly loses its market share in the Gulf region.

A few examples of what standards will mean to American exporters may help to illustrate our point.

- a U.S. exporter have fava beans for 20 years lost his market because his beans are packed in oil, not water.

- some U.S. manufactured refrigerators were not allowed in the Kingdom because of the improper length of the power cord.

- a container of varied goods was delayed in port for months because the wires on the heating element for the ink pot of the labeling machine did not have the proper certificate.

Mr. Chairman, the point is a simple one. U.S. participation in the standards proceedings of SASO will preserve access to the Saudi and Gulf markets for American exporters. This market has been a strong one for American business and can remain one with your support now for Congressman Dymally's authorization measure, HR 2468, and an appropriation.

American companies are being outflanked by competitor nations such as Japan, the U.K., Germany and France who have sent teams of standards expert to Riyadh. The SASO standards will be adopted by the other members of the Gulf Cooperation Council and cover everything from food shelf life to wire insulation colors. The share of U.S. exports has been slipping. At one time the U.S. dominated the market; today Japan is the leading exporter.

Enclosed is an article from Forbes which illustrates what U.S. competitor nations are doing to advocate for their domestic industrial standards in the GCC and elsewhere.

Thank you for your interest in this matter.

Respectfully,

Mark Woodbridge
Government Affairs

Enclosure

*Wonder why we have this gaping balance-of-trade deficit? There are lots of reasons, but here's one that most folks overlook.*

# Who sets the standards?

By John R. Hayes

GENERAL ELECTRIC's business in Saudi Arabia has been threatened since early last year, when a container of gas turbine parts was held at the port of Dammam. The hang-up? One oil heater didn't conform to new Saudi electrical standards. Customs officials have also stopped shipments of goods from Clorox and Westinghouse. Eventually storage and shipping penalties caused so much screaming and arm-waving that the Saudis declared a moratorium on enforcing their new rules, but product standards remain a threat to U.S. exporters.

Were GE and Clorox shipping shoddy goods to Saudi Arabia? No such thing. Product standards deal not so much with quality but with uniformity in size, materials and performance. So what happened?

Simply, the U.S. companies let themselves be outflanked. Japan, the U.K., Germany and France have sent teams of standards professionals to Riyadh to advise the Saudi Arabian Standards Organization (SASO) on its 16-year-old project to develop product standards. SASO expects to write 42,000 standards, covering everything from the shelf life of lamb to the color of ground wires in air conditioners. Not surprisingly, our competitors argue for standards that favor their own manufacturers.

A U.S. representative could argue differently, but there isn't one around. Every six months or so the Saudis renew an invitation to the U.S. government to send a U.S. standards expert to Riyadh. SASO even offered to pick up housing, office and local transportation expenses if the Commerce Department would recruit someone. Overruling his staff, former Secretary William Verity, citing the expense, passed up the invitation once again last spring.

Much is at stake. The U.S. used to dominate trade with Saudi Arabia. But since 1982 U.S. exports have slipped from 21% to 15% of total Saudi imports. Today Japan has the biggest piece of the market.

Since other countries in the Persian Gulf—Bahrain, Kuwait, Oman, Qatar, and the United Arab Emirates, all members of the Gulf Cooperation Council—will adopt Saudi standards as they are written, an additional $1.5 billion of U.S. exports is at risk.

The Persian Gulf isn't the only area of the world where product standards have trade implications, or where the U.S.' competitors have been quick to react. Consider Brazil, for example, which imports some $17 billion worth of goods. The library at the national standards clearinghouse contains about 70 shelf-feet of German product standards, *in Portuguese*. A gift from a German construction company, these volumes have become the principal reference for standards development in Brazil. U.S. standards are represented by one shelf of 5-to-20-year-old copies of assorted trade association publications.

In India, where $40 billion will be spent on telecommunications equipment in the next decade, Europeans have spent over $16 million equipping a laboratory outside New Delhi to certify that locally made electronic components meet European specifications. The thinking: If India can sell components to Europe for use in European-built transponders, satellites and computers, it will earn the hard currency it needs to buy the finished products from Europe.

Japan's Ministry of International Trade & Industry currently has technical experts working abroad on five nations' standards programs. MITI has also brought standards personnel from 28 developing countries back to Japan, expenses paid, for language and technical training.

Why can't the U.S. counter the influence of the Japanese and the Germans? There is no central clearinghouse for product standards in the U.S. as there is in most other countries. The government is not involved. Instead, some 400 private and public groups develop standards for the various industries. And these groups haven't shown much interest in foreign standards.

So far the lone effort to protect trade with Saudi Arabia comes from legislation introduced by Congressman Mervyn Dymally (D–Calif.). The law, enacted last fall, directs Commerce to accept the Saudi invitation—and similar invitations from other trading partners—but to get the funding from private business.

That may prove more easily said than done. A group called the American/Saudi Roundtable is heading the fundraising effort, but things are not going well. Seems that the Roundtable's letters keep getting forwarded to the Corporate Philanthropy Office. So far the outfit has collected two sincere letters of support, from the U.S. Chamber of Commerce and the National Association of Manufacturers, but only about $85,000 in hard cash. That's one-third of what's needed to fund U.S. involvement for one year. A similar effort by German industry raised $5 million in 20 days.

Old habits die hard. For generations, U.S. business had its own huge market to sell to and simply didn't think much about exporting. Listen to Robert Toth, an American standards consultant to the World Bank: "American exporters still have a take-it-or-leave-it approach to their products," he says. "They say, 'We produced it to the UL standard. If it's good enough for the U.S., it's good enough for you.' " Faced with that attitude, a lot of foreign buyers are leaving U.S. goods alone. ■

MERVYN M. DYMALLY
THIRTY-FIRST DISTRICT
CALIFORNIA

1717 LONGWORTH BUILDING
WASHINGTON, DC 20515
(202) 225-5425

JUN 14 1989

COMMITTEES:
FOREIGN AFFAIRS
CHAIRMAN, SUBCOMMITTEE ON INTERNATIONAL OPERATIONS
DISTRICT OF COLUMBIA
CHAIRMAN, SUBCOMMITTEE ON JUDICIARY AND EDUCATION
POST OFFICE AND CIVIL SERVICE

**Congress of the United States**
**House of Representatives**
**Washington, DC 20515**

June 8, 1989

The Honorable Doug Walgren
Chairman
Subcommittee On Science, Research,
And Technology
2241 Rayburn H.O.B.
Washington, D.C. 20515

Dear Mr. Chairman:

Pursuant to our conversation last week, I would like to thank you for agreeing to consider authorizing funding for the pilot project authorized in Section 112 of Public Law 100-519.

This pilot project, which required the Department of Commerce to provide technical assistance to the Government of Saudi Arabia in developing its national mandatory product standards, is crucial to maintaining our share of an already dwindling export market.

Section 112 of PL 100-519 directed the Department of Commerce to establish the pilot project, and later be reimbursed by private sector funds. The results of this effort, fully six months after entrusting Commerce with it, compels me to seek government support.

Six months of fundraising from the private sector barely raised sufficient funds for one year of operation for this program. Though one can speculate on the reason(s) for the failure of this approach, one conclusion is evident: The private sector needs governmental assistance if it is to effectively compete with foreign corporations whose governments readily subsidize their participation in developing industrial product standards. Once these standards are formulated by the Saudi Arabian Standards Organization (SASO) all five countries of the Gulf Cooperation Council Countries (whose U.S. imports in 1988 totalled $5.7 billion) will adopt them as their own national mandatory product standards.

With the increased influence of product standards as trade barriers or facilitators, it is no wonder that several European countries and Japan sent in experts to provide standards

information to SASO. Already, information supplied by our competitors resulted in adoption of product standards incompatible with ours. U. S. participation in the SASO project is necessary to ensure that SASO develops standards compatible with those used in the United States. Failure to participate could jeopardize our ability to sell goods in the Gulf State markets. Maintaining U.S. exports to the Gulf Cooperation Council Countries (GCC) at present levels is important in more ways than one. It is acknowledged that a billion dollars worth of exports generates 30,000 jobs in the United States. As such, what is at stake here is not only our export market share, but the 165,000 jobs generated within the United States as a result of our exports to the Gulf Cooperation Council Countries.

According to the American Embassy in Saudi Arabia, we can increase our current exports by as much as $500 million annually, if Saudi standards were compatible with the U.S. Such an increase would create 15,000 new U.S. based jobs. Based on a federal tax payment average of only $1,000 per taxpayer, these new jobs will generate at least an additional $15 million in U.S. Government tax revenues.

The $200,000 annual authorization in H.R. 2468 will essentially allow the National Institute of Standards and Technology (NIST) to coordinate a program of assistance which will include placing a standards specialist in Saudi Arabia to assist SASO in developing product standards transparent to our industrial goods. I would like to emphasize that this authorization does not constitute full funding by the Federal government. Rather, it would merely allow NIST to initiate and coordinate the program through an on-site standards specialist. The private sector will be called upon to provide information or experts when needed on an industry basis.

I would appreciate your inclusion of H.R. 2468 as part of the National Institute of Standards and Technology authorization for FY1990, 1991, and 1992 .

Sincerely,

MERVYN M. DYMALLY
Member of Congress

MMD/mb

I

101ST CONGRESS
1ST SESSION

# H. R. 2468

To authorize the appropriation of funds for a pilot program to assist other countries in the development of their domestic industrial standards.

---

IN THE HOUSE OF REPRESENTATIVES

MAY 24, 1989

Mr. DYMALLY introduced the following bill; which was referred to the Committee on Science, Space, and Technology

---

# A BILL

To authorize the appropriation of funds for a pilot program to assist other countries in the development of their domestic industrial standards.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That there are authorized to be appropriated to the Secretary of Commerce for each of the fiscal years 1990, 1991, and 1992, $200,000, for the establishment of a pilot program, under section 112 of the National Institute of Standards and Technology Authorization Act for Fiscal Year 1989, to assist in the development of comprehensive industrial standards for a country or countries that have requested such assistance from the United States and will require the continuous pres-

ence of United States personnel for a period of 2 or more years to provide such assistance.

O

HARRY JOHNSTON
14TH DISTRICT, FLORIDA
COMMITTEE ON FOREIGN AFFAIRS
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

CHIEF OF STAFF
SUZANNE STOLL
DISTRICT ADMINISTRATOR
DIANE BIRNBAUM

# Congress of the United States
## House of Representatives
### Washington, DC 20515

JUN 13 1989

June 12, 1989

Hon. Doug Walgren
U.S. House of Representatives
2319 Rayburn HOB
Washington, D.C. 20515

Dear Chairman Walgren:

I am writing to express my strong support of Representative Dymally's legislation, H.R. 2468. I had the opportunity to meet with a number of American businessmen from the Gulf area, and I was dismayed to learn of U.S. unwillingness to pursue such a clearly beneficial opportunity among the Gulf Arab States.

American participation in the determination of the standards issue in the Gulf States deserves the full support of our government, especially at a time when additional export revenues are greatly needed to offset our trade deficit.

Japan, West Germany, Britain, Holland, Finland, India, New Zealand and Singapore have all responded to the Saudi invitation to participate in this important process by sending at least one representative, sometimes an entire team. I would hope the U.S. could send at least one representative, especially when our participation has been actively encouraged by the Saudis. The U.S. Embassy in Riyadh has estimated that if Saudi Arabian and U.S. standards were harmonized, U.S. exports may increase by as much as $500 million per year.

As a member of the Subcommittee on Science, Research and Technology and the Subcommittee on International Economic Policy and Trade, I am convinced of the need to fund our representation. Thank you for your attention to this important matter.

With warm regards,

Sincerely,

HARRY JOHNSTON, M.C.

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# Library of Japanese Science & Technology

*Librarian: R. Phillifent B.Sc.*
LJST: 24, Duke Street, Whitley Bay, Northumberland, United Kingdom. Telephone: 0632 533479

Hon. Doug Walgren.
House Committee on Science and Technology.
Washington D.C.
U.S.A.

Our Ref. ESTL/RC-82.

31st May, 1989.

Dear Mr. Walgren,

It is quite some time since I wrote to you regarding your deliberations on U.S. Competitiveness with Japan and the Japanese Literature Act of 1986. The materials you sent me have proved very interesting and useful.

I was a delegate at the International Conference on Japanese Information in Science, Technology and Commerce which was held at Warwick in September 1987. Some of your countrymen, for example Mr. D.B. Shonyo of NTIS, Ms. S. Javits of DoC and Ms. Frieman of SAIC gave presentations which were both interesting and informative. However, I got the distinct feeling that the spirit of the Japanese Literature Act is being frustrated by a distinct unwillingness on behalf of the U.S. Government to supply the funds necessary - only 300,000 dollars having been allocated in 1987. I know that intially you and your colleagues in the Congress had requested 1 million dollars but in the letter you received (Report 99-618) from the Deputy Secretary of Commerce (8th. May, 1986), the Department wanted all mention of an amount of money deleted entirely from the Bill!

I am very interested in what progress, if any has been made under the provisions of the Japanese Literature Act - I believe that one requirement was that regular reports be submitted to the Congress detailing work and progress made under the Act. If any have been produced I would be pleased to receive copies.

It is interesting to compare the rather "laid-back" approach of many individuals, public and private organisations in the U.S. to the Japanese commercial and technological "threat" with the state, bordering on hysteria, that proceeding the launching of Sputnik in 1957. The latter, as you well know, resulted in the National Defense Education Act and a HUGE budget allocation for the translation "cover to cover" or virtually any technical journal published in the USSR. Much of this was a waste of time and money but money was found for it. Of course in 1957 the threat was perceived as "military" and the USSR regarded as a "enemy". I wonder how less difficult your efforts would have been had the Japanese connection been seen as military rather than scientific and commercial. Just a thought!

MORE

[日本科学技術図書館]

I enclose for your attention a copy of our library brochure which I hope will answer some of the questions that you might have about L.J.S.T.

In conclusion I might just say that our own library sometimes receives requests for Japanese technical serials from the U.S. A one was received recently for a fairly recent journal published by an academic/industrial society. While I am flattered to know that L.J.S.T. is able to supply ac copy of the article wanted I am also somewhat concerned that in the whole of the U.S.A., which has many more libraries with considerably greater resources than those in the U.K., the requesting library could not find a single one that had the publication needed! This poses an important question which is also relevant in our own country: "Are people <u>really</u> interested in Japanese scientific and commercial information?"

Yours sincerely,

R. PHILLIPSON, B.Sc.
Librarian

1019

THE UNIVERSITY OF NEWCASTLE UPON TYNE

THE LIBRARY

OF

JAPANESE SCIENCE AND TECHNOLOGY

日本科学技術図書館

## THE LIBRARY OF JAPANESE SCIENCE AND TECHNOLOGY

Newcastle upon Tyne — the capital city of the North East of England — holds the only library in Europe to specialize solely in works about Japanese science and technology. This remarkable library, called the Library of Japanese Science and Technology, contains a very large proportion of the specialist journals relating to science and technology printed in Japan today.

Altogether there are about 3,000 'live' journals covering such fields as physics, chemistry, medicine, pharmaceuticals, dentistry, various aspects of engineering, shipbuilding, agriculture, acoustics, pollution, communications, social sciences, textiles and food. In addition there are university bulletins, reports of government experimental stations, the 'white papers' of the science agencies of the Japanese government and company reports. Outside the strictly scientific field and more related to commerce and industry there are patent abstracts and statistical yearbooks, an area which is expanding rapidly. While most of the publications are, naturally, in Japanese, many have abstracts in English and some are entirely in English.

The Library is the personal collection of Bob Phillifent, a high school science teacher and a chemistry graduate of Newcastle University, but is housed at the centre of Newcastle University in the Old Library Building. Bob Phillifent has been collecting these specialist science journals since 1961. At that time very few Japanese journals were available in the UK, and they had generally been obtained by universities on an exchange basis. The origins of the Library lie in Bob Phillifent's belief that, if there was a separate library which collected Japanese specialist journals systematically, aiming to be as comprehensive in its coverage as possible, access to the material would be much easier for British users. He wrote to the publishers of the journals to explain the purpose of the library he intended to set up, and its significance. He seems to have convinced them, because they began to donate their publications, and have continued to do so.

As the collection has grown it has changed its location: first from the bookshelves of his house to a garage, then to the disused waiting room of Monkseaton Metro Station, and finally, in October 1984, to accommodation at Newcastle University vacated by the University Library. Its location within the University affords many advantages but the collection remains, as before, the personal collection of Bob Phillifent, and he alone is responsible for its administration and organization.

Bob Phillifent welcomes visitors to the Library, and enquiries. For information about opening hours, see below.

### Opening Hours

| | |
|---|---|
| Monday, Tuesday, Wednesday and Friday | 9.00 am — 1.00 pm<br>2.15 pm — 6.30 pm |
| Thursday | 9.00 am — 1.00 pm<br>2.15 pm — 5.00 pm<br>5.30 pm — 7.30 pm |

For access outside these times, please contact Mr Phillifent direct.

Further details may be obtained from:

Mr R. Phillifent
24 Duke Street
Whitley Bay
NE23 3PP
Tel: (091) 253 3479

*or*

The University Library
The University
Newcastle upon Tyne
NE1 7RU
Tel: (091) 232 8511, ext 2693

# 日本科学技術図書館

英国北東部の中心地ニューカッスル市には、ヨーロッパではただ一つという日本の科学技術書専門の図書館があります。正式名称を「日本科学技術図書館」(The Library of Japanese Science and Technology)というこの図書館には、現在、日本国内で発行されている科学技術関係の専門書のほとんどが収集されています。医学、薬学、歯学、工学各分野、造船、農業、音響学、公害、通信、繊維、食品などの科学技術分野の各ジャーナルや、全国主要大学の学部別紀要、政府試験場報、政府科学技術関連白書、民間会社社報といった全部で約3千種類の図書が揃っています。また科学技術以外にも、Patent Abstracts、統計年鑑などの商業関係誌も収集されていて、この分野での蔵書は今後さらに増えていく見込みです。

ニューカッスル大学の旧図書館の建物の中に設置されてはいますが、日本科学技術図書館は、英国北東部地方に在住の、ボブ フィリフェント氏の私設図書館です。現在、高校の化学教師であるボブ フィリフェント氏は、1961年以来、こういった日本の科学技術専門書を収集してきました。当時は、英国内では、日本の文献は非常に少なく、日本から取り寄せる場合には、大学図書館の資料交換という制度しかなかったそうです。日本の専門誌を収集している図書館があれば、文献はもっと簡単に手に入るのでないかと考えたのがフィリフェント氏の図書館の第一歩でした。以来、フィリフェント氏は、種々の図書の発行所に科学技術図書館の設置の意義を書き送り続けました。その結果、フィリフェント氏の意図に賛同する発行所から次々に図書が送られて来るようになったのです。

収集が増えていくにしたがって、その収納場所も変わっていきました。フィリフェント氏の書斎の本棚からガレージへ、そして古い鉄道の駅の建物を借りたりもしました。1985年より、この図書館はニューカッスル大学内の旧図書館内に移転しました。大学内に移転したことは、利用者にとってはさらに便利に、また図書の管理にとってもより良いものとなりました。しかしながら、日本科学技術図書館が、フィリフェント氏の私設図書館であることは変わらず、図書の管理や入手は、全てボブ フィリフェント氏が行っています。

| 開館時間 | | | |
|---|---|---|---|
| 月曜日、火曜日、水曜日、金曜日 | 9時00分 | — | 13時 |
| | 14時15分 | — | 18時30分 |
| 木曜日 | 9時00分 | — | 13時00分 |
| | 14時15分 | — | 17時00分 |
| | 17時30分 | — | 19時30分 |

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June 21, 1989

Dr. James Turner
Ms. Carol Pompliano
Committee on Science and Technology
U.S. House of Representatives
Washington, DC

Dear Jim and Carol:

As you know, I have been involved in U.S.-Japan science and technology matters for a number of years. I have prepared a paper for presentation to the 2nd International Conference on Japanese Information in Science, Technology and Commerce to be held in Berlin in late October 1989. A copy of this paper with a separate page on recommendations is enclosed.

I am hoping that you could include some of the recommendations in the Commerce Department's NIST markup. I am referring in particular to the upgrading of the Office of Japanese Technical Literature as suggested. If the Japanese S&T challenge is a serious matter we should be serious. This Office has now been organizationally downgraded to a Program under Commercial Services Office in the Technology Administration. Let's upgrade- not downgrade - this endeavor. Let's get the signal out that we are serious by emphasizing it.

Secondly, let's request Commerce to make a national assessment of machine translation and create a national plan with a five year budgetary plan by December 31, 1989. At this time, the Office of Japanese Technical Literature has provided some funds to the Office of Japan Affairs in the National Academy of Sciences to conduct a conference in November to assess machine translation and U.S. needs. This is one of the results of a letter from Congressman Walgren to NBS in April 1988.

Thirdly, request Commerce to conduct a cost analysis of a full-fledged JSTI program to see whether a coordinated program could be cost effective.

Fourthly, ask Commerce to devise a plan to strengthen library collections on JSTI in the U.S.

Fifth, it would be wonderful if Secretary Mosbacher and Deputy Secretary Murrin would earnestly, continuously and systematically carry out recommendation no. 4. It would surely prove that the U.S. government is serious about the JSTI issue and is going to do something about it.

Good luck

Cecil

Cecil H. Uyehara

## U.S. Responses to the Japanese S&T Challenge

### Recommendations

The overarching and fundamental requirement in carrying out the following recommended actions (except #3) is that industry, academia and government act together in concerted, continuous and systematic cooperation. In any set of actions doing the basics correctly is necessary; however, since the actions for this objective are beyond the scope of these recommendations, the following are limited to a much narrower and hopefully more realistically achievable set of actions:

1. formulate our response to the Japanese Challenge as part of our total S&T posture NOT as a special U.S.-Japan bilateral response,

2. since we appear to be obsessed with the Japanese Challenge at this time, and assuming it is of such consuming importance, various coordinated actions should clearly have the active support of the highest levels of government otherwise there is little hope that such an effort can be effectively created and carried out,

3. raise the status of the Office of Japanese Technical Literature by making it part of the office of the new Under Secretary of Commerce for Technology as not only a symbolic message but a statement of bona fides that the U.S. government is serious,

4. launch a joint campaign to raise consciousness among U.S. scientists and engineers. It is recommended that either the Secretary himself or at least the Deputy Secretary would commit their PERSONAL determination, enthusiasm AND time to leading this campaign. Begin with a campaign (jointly with NSF) with academia, and industry to publicize the findings and implications of the JTech studies for the U.S.,

5. conduct a cost analysis of a full-fledged JSTI program to see whether a coordinated program could be cost effective and culturally/administratively/politically feasible,

6. accelerate the development of a U.S. machine translation capability with a determination to include a financial commitment in the FY1991 budget,

7. devise a plan to strengthen S&T library collections in the U.S.,

8. accelerate Japanese language training, if necessary with Federal funding assistance.

# U.S. "Responses" to Japanese Science and Technology "Challenges"

by

**Cecil H. Uyehara**
**Uyehara International Asociates**

For Presentation to the
2nd International Conference
on
Japanese Information in
Science, Technology & Commerce

October 23-25, 1989

Japan-German Center

Berlin

# U.S. "Responses" to Japanese Science and Technology "Challenges" -- A Case Study --

Cecil H. Uyehara
Uyehara International Associates

**Summary**

It is truism to state that it requires a massive effort to change the direction and inertia of a movement and the consciousness of a movement and the consciousness underlining that movement. During the past ten years, there has been a gathering momentum in the U.S. to appreciate - and to be wary of - the Japanese technological and scientific challenge through a variety of means. A few of these activities are probably well known outside the U.S. This paper describes and assess the broad range of activities that have taken place in the U.S. to respond to this Challenge. These activities are discussed under the following headings: consciousness-raising activities, federal legislative action and international agreements, educational activities, marketing of Japanese science and technology information, institutional developments, evaluations of Japanese science and technology, library collections, technical developments, surveys of the utilization of Japanese science and technology information and a conclusion.

# U.S. "Responses" to Japanese Science and Technology "Challenges" -- A Case Study --

**Cecil H. Uyehara**
**Uyehara International Associates**

A. Introduction
B. Consciousness-raising Activities
C. Federal Legislative Action & International Agreements
    1. The Japanese Technical Literature Act of 1986
    2. Technology Transfer Legislation & Agreements
D. Educational Activities
E. Marketing of Japanese Science and Technology Information
F. Institutional Developments
G. Evaluations of Japanese Science and Technology
H. Library Collections
I. Technical Developments
J. Surveys of JSTI Utilization
K. Conclusion

## A. Introduction

Over the past forty plus years, disagreements, confrontations, conflicts, or however one wishes to characterize them in emotionally loaded terms between the U.S. and Japan have escalated on the technology scale from textiles, TV, steel, automobiles, computers, to semiconductors. While the debate was over specific products, the scale, depth, intensity and sophistication of the technologies involved in manufacturing these products gradually increased to where the most advanced technologies in the world have now become involved in this relentless competition between the U.S. and Japan. Throughout this at times rather acrimonious dialogue, "science and technology" (S&T) per se was not, until relatively recently, an issue, was not really discussed, nor was it a serious concern for U.S. policy makers, nor the private sector judging from the lack of stated concern. Science and technology, together with security relations with Japan, have been described as immune to these unpleasantries. As far as S&T is concerned, probably it would be more accurate to say that the U.S.-Japan S&T relationship just grew into its present interlocking web without a particular plan on either side, with the general sense, feeling and sentiment that this was a good thing to do without a specific evaluation/assessment as to its consequences.

Writing in the mid-1980s, the former U.S. science counselor in the American Embassy described the public sector S&T relations between the U.S. and Japan as the most deeply involved and inter-related of any between the U.S. and any other country in the world. For example, the 1961 agreement between the U.S. and Japan on the exchange of scientists and S&T projects is the oldest of any such agreement, is still operative, and was described in the annual Science, Technology and American Diplomacy, 1987 (p. 28) as "a model for bilateral S&T agreement with many other countries."

With the growing U.S. trade deficit with Japan, the persistent refusal of U.S. productivity to improve substantially, the implications of the rising Federal budget deficit, and the seemingly absolute need to recognize that Japanese science and technology was rapidly approaching that of the U.S. and Europe in many fields, a developing anxiety about the S&T challenge from Japan began to creep into the consciousness of a small coterie of people in the U.S. government, in academia and presumably in the private sector, except that the latter is most of the time difficult to detect. There was a convergence of factors which demanded a reassessment of our S&T relationship with Japan.

In the annual report referred to above, there is a gradual shift in the assessment of U.S.-Japan S&T relations. They are described as having served an "overriding U.S. foreign policy interest for more than 30 years with Japan". (ibid, p.27). By 1986, the U.S. objective of integrating Japan into the community of advanced Western industrial democracies has been a "resounding success." By that time, Japan had made so much progress "in an impressive range of advanced technologies" that this has now introduced "a new dimension into the bilateral relationship: the importance of the U.S. remaining abreast of Japanese S&T activities." (ibid, p. 27).

Seeing its pre-eminent position in high-technology challenged, the U.S. began to call for, among other things, the opening up of Japanese high tech markets, a freer exchange of S&T research and data, greater access to Japanese laboratories by American scientists and engineers, then began to demand these ever more strongly, and in its frustration began to raise the decibel count ever higher. Each year the crescendo seems to rise higher. The actions we are asking the Japanese to take are probably similar to what they mean when they say they should "internationalize" - a buzz word in Japan nowadays. How should the U.S. respond to this Japanese Challenge? While getting the basics right, e.g. revamping our grade and high school expectations, rearranging our intellectual vs sports priorities, would be a fundamental response, this is an issue which cannot be discussed in a worth while manner in a short essay. Perhaps by drastically narrowing the area of response, we might be able to glimpse the willingness of the United States to make internal adjustments to respond to a somewhat amorphous external Challenge.

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The purpose of this essay is to survey and assess the U.S. responses to this "new situation". It is, in a way, a limited case study. I have grouped these various responses into nine categories beginning with various "consciousness raising activities, e.g. workshops, symposia, conferences, congressional hearings. Other categories are legislative action, educational activities, efforts to market Japanese science and technology information (JSTI), institutional developments, evaluations of the level of specific technical fields in Japan, technical developments, and surveys of JSTI utilization. This is not intended to be an academic essay replete with footnotes, but rather an operational report of how the U.S. seems to be reacting to the Japanese challenge basically viewed from the Washington point of view - from inside the Beltway. This is not intended to be a completely exhaustive presentation of all activities which could be cited and characterized as part of the U.S. response. Furthermore, I have excluded such major activities as all the on-going S&T cooperative research projects between U.S. and Japanese government agencies, e.g. the long standing National Science Foundation (NSF) program of science exchanges with Japan, because these projects long antedate the present anxieties and frustrations, U.S.-Japan joint ventures and the establishment of research laboratories in Japan by U.S. firms. I will try to assess whether these groups of activities in whole or in part are providing a satisfactory and adequate response to the Japanese Challenge.

**B. Consciousness-raising activities.**

This category has been rather broadly interpreted to include conferences, seminars, symposia, Congressional hearings, and even governmental advisory committees and bilateral businessmen's

conferences.

Until the early 1980s, assessments, comments, surveys of Japanese S&T (and such relations with the U.S.) were made in connection with economic analyses (e.g. Japanese-U.S. relations in science and technology by Takeo Sasagawa in Japan and the U.S.: Economic and Political Adversaries, 1979 and Merton J. Peck on Technology in Asia's New Giant: How the Japanese Economy Works, 1975). In seminars and symposia, Japanese science and technology, if discussed at all, seemed to be included at the end of the meeting as an afterthought. This non-interest must reflect an assessment of the value and potential challenge of Japanese S&T. One of the earlier surveys of Japanese S&T - for the purposes of this essay - was by General Motor's Research Library which issued a report with recommendations in 1979 (R.W. Gibson and B.K. Kunkel, Japanese Scientific and Technical Literature: A subject guide, 1981, 560 p.) It listed almost 10,000 Japanese technical journals that might be of some interest to GM with a short commentary and the following recommendations:

1. Governmentally supported efforts to survey published Japanese scientific and technical information similar to that inaugurated for Russian literature after the advent of Sputnik.

2. Encouragement in implementation of cooperative programs between Western indexing and abstracting services and the Japan Information Center of Science and Technology.

3. Increased dialogues between Western and Japanese librarians, similar to those reported in the proceedings of the Japan-U.S. Conferences on Libraries and Information Science in Higher Education, by emphasizing specially the need for greater Japanese emphasis on bibliographical control as well as more effort towards indexing and abstracting journal articles and reports.

4. A concerted effort by the major Western academic and corporate libraries to improve their holdings of Japanese scientific and technical periodicals.

These are cited in full here not because of their originality but because of their continuing relevance in the late 1980s! To the best of my knowledge nothing concrete evolved from these recommendations.

The first symposium devoted exclusively to S&T exchange between the U.S. and Japan was organized by this author under the sponsorship of the Japan-America Society of Washington, DC, in October 1981. It was not intended to create a set of recommendations but rather to engage American corporate and government R&D managers in a dialogue amongst themselves and with Japanese participants. At that time, the emphasis was still perceived as a one-way flow from the U.S. to Japan. The case studies presented at the Symposium did provide examples, however, where the flow was beginning to be more of a two-way street between the two countries. This author was asked to organize the second such symposium in November 1986. During this interval of five years, the milieu had substantially changed; there was now a much greater emphasis and recognition of Japan's contribution to S&T exchange between the two countries. Unlike the 1981 meeting, the 1986 meeting concluded with a paper on policy options for the U.S. by Justin Bloom, former science counselor in the U.S. Embassy in Tokyo (cited on p. 1).

Beginning in the early 1980s to about 1985-86, there were a series - one might say a spate - of workshops in MIT in Cambridge, MA, the National Science Foundation in Washington, DC, and the National Bureau of Standards (NBS, now called the National Institute of Standards and Technology, NIST) in Gaithersburg, MD, the Woodrow Wilson Center in the Smithsonian Institution in Washington, DC, the U.S. Office of Naval Research. In the beginning, the workshops at MIT and NSF were comprised of a small group of individuals from the government, academia and industry who were greatly concerned with the trends they detected

in the U.S. and the lack of concern for taking Japanese S&T more seriously. Basically the like-minded were talking to each other. The several other workshops gradually reached a wider audience and strived to raise the consciousness of the private sector to the Japanese Challenge. Often, this was also an opportunity for small firms to describe what they were doing and how they could contribute to the private sector's grasp, understanding and utilization of Japanese S&T. Although specific sets of recommendations were not always formulated, a workshop sponsored as recently as 1986 by the NSF and Office of Naval Research on monitoring foreign science and technology and defining U.S. needs, had five pages of ideas on what might be done. (Monitoring Foreign Science and Technology for Enhanced International Competitiveness: Defining U.S. Needs, p. 82-86). Only a sampling will be mentioned here: in the short term - disseminate trip reports, create panel sessions on reporting foreign S&T, encourage more grants for international scientific visits, establish data bases which are user driven for public and private sectors, establish more industry association offices in foreign countries, encourage wider attendance at foreign trade shows, emphasize the advantages of using university faculty to assess foreign S&T, help develop with government assistance a new generation of technical specialists possessing language skills, develop university/industry/state/federal consortia to improve information about foreign research. These are fairly obvious and ordinary ideas but all should be carried out if a more effective appreciation of the Japanese Challenge is to be achieved. The amazing and sad thing is that the obvious still needs to be stated in a document which probably did not receive very wide dissemination either in the government or in the private sector or in Congress.

The Congress has held numerous hearings over the years on the achievements of the Japanese economy since 1945, on lessons to be learned from Japanese productivity, the value of joint ventures to counter Japanese S&T advances. It had not held a hearing specifically on the Japanese S&T challenge and the availability of JSTI until for the first time hearings were held in March 1984 - and these hearings came to pass only because of persistence and connections. The committee report of the hearings noted that numerous recommendations had been made by the several witnesses. These ranged from assessing the current holdings of Japanese S&T journals in Libraries and user needs, the potential value of JSTI to Americans, increase language capabilities and qualified translators, support of a translation service by the Federal government, increase international travel for scientists and engineers, increased responsibilities for National Technical Information Service (NTIS) and NIST in the acquisition of JSTI, and the formulation of a federal information policy which does not now exist in contrast to Japan, France, and West Germany.

The House S&T Committee authorized $750,000 for FY1985 for Commerce's Office of Productivity, Productivity and Innovation to increase JSTI availability in the U.S. A super modest sum for this large assignment. Nevertheless, in the parliamentary confusion after a Presidential veto, this tiny beginning was lost in a procedural shuffle. (An attempt was also made in May 1983 to provide $175,000 to NTIS to make JSTI available in the U.S.).

The following three activities would not normally be regarded as consciousness raising efforts. They are extremely serious efforts at keeping the channels of communications open, attempting to improve the dialogue and create an atmosphere for a more constructive understanding and basis for future cooperation between the business groups of the two countries. They are included because of the heightened need for such channels of communications between the business leadership of the two countries.

1. The Advisory Council on Japan-U.S. Economic Relations which has been in existence for 25 years consists of 75 senior U.S. business leaders whose firms have significant involvement in U.S.-Japan commerce. Its counterpart in Tokyo is the Japan-U.S. Economic Council. Its objectives are to provide a forum to propose solutions to problems within the Japan-U.S. economic relationship and to stimulate and facilitate business relations between the two countries. The two groups meet every year alternately in the U.S. and Japan. For the first time in 1984, the U.S. Council issued a "High Technology Position Paper" covering changes in

Japanese telecommunications industry, protection of software and the Japanese government's legislation plans to promote Japanese high technology industries. The critical achievement of these efforts is the dialogue that takes place at a high level in both countries, the results of this dialogue probably are transmitted to correspondingly high governmental levels on both sides and does raise the "consciousness" of the bureaucracy and sensitize the political leadership to industry's viewpoints on selected subjects.

2. U.S.-Japan Advisory Commissions, commonly referred to "The Wisemen's Group" were appointed by Presidents Carter and Reagan, respectively. While these Commissions were created through Summitry, with senior business and labor leaders, academicians, former Ambassadors, etc appointed to the Commission and supported by senior staff, they were clearly in response to the trying economic relations plaguing both countries and obviously an attempt to defuse the situation with more dialogue. The first report of 1979 did not include comments on S&T.

It is significant, however, that the September 1984 report, Challenges and Opportunities in United States-Japan Relations, for the first time, included a separate chapter on science and technology, with several useful annexes two of which should be mentioned. Justin Bloom former prepared the first history of U.S.-Japan S&T relations since 1945 with numerous recommendations for future action; Ellen S. Frost, then of Westinghouse and now with United Technologies Corporation, wrote on U.S.-Japan security relations in the 1980's and beyond including S&T relations.

In light of what transpired during 1986-88 when the 1988 U.S.-Japan S&T Agreement was created, it is noteworthy that this report asserted that "There is now an excellent qualitative balance in the flow of technological ideas between the two countries" (p. xvii), the scope and depth of scientific and technological cooperation between the U.S. and Japan is unique, and that the overall S&T relationship is in "excellent qualitative balance." (ibid, 97-98). Among the many recommendations in the S&T area, it singled out five for special mention: 1) review of 13 government-to-government S&T agreements for possible improvements and new directions (conducted unilaterally by the U.S. Department of State in 1984, not by the Japanese government or jointly), 2) Japan should take a stronger role in the generation of basic knowledge (Japan is moving in this direction), and the U.S. should devote greater attention to new-product innovation and production technology (the U.S. is moving with glacial speed in this area), 3) joint efforts between U.S. and Japanese high technology firms should be encouraged, particularly where initial costs of product development are high (difficult to assess), 4) increase opportunities for U.S. and Japanese scientists to have greater access to each other's research including increased Japanese language training for Americans (partially executed but highly inadequate), 5) creation of a joint advisory body to examine technical standards development for purposes of harmonization (abandoned). While this report provided food for thought in the S&T area for a minuscule number of devotees in this area, the report was soon covered with historical dust.

3. Beginning in the summer 1985, the first of two meetings of high level personages from the U.S. and Japan met in Santa Barbara, CA, to discuss advanced technologies and the international environment. The membership included Japanese and U.S. industry leaders, academicians, and the representatives of the national academies of science and engineering. No formal report is available from these deliberations. The second meeting took place in November 1986 in Kyoto. It called for "symmetrical access" rather than "identical access" to all elements - basic research, technology development, product markets, and financing - necessary for the commercialization of new technology. It also called for the conduct of certain studies, and bilateral workshops on selected topics and recognized that the Japanese were considering the creation of a Japanese Academy of Engineering. The concept of "symmetrical access" appears to have filtered through to the 1988 U.S.-Japan S&T Agreement through hard labor and tortuous debate. The Japanese Academy of Engineering was subsequently created, but the studies and bilateral workshops have been held in abeyance since 1984. The impact of this high level meeting seems to have had mixed results.

These efforts at consciousness raising have been sporadic, depended on the drive of a few interested persons, financially supported in some cases by government and corporations but sparsely attended by senior level corporate executives. Despite the financial support, the lack of corporate participation was exceedingly conspicuous.

### C. Federal Legislative Action and International Agreements

#### 1. The Japanese Technical Literature Act of 1986

The only legislation in direct response to the Japanese S&T challenge was the Japanese Technical Literature Act (JTLA) of 1986 signed into law in August 1986. Earlier in 1984, an attempt was made to pass a similar kind of bill in the House but it fell by the wayside. As described above, an authorization bill was passed by the House but it was lost in the legislative shuffle in the appropriations process. Senators Nelson Rockefeller and Max Baucus sponsored the JTLA in 1986 but the Reagan Administration apparently did not feel the need for such an office and was quite reluctant to agree to the proposed funding of one million dollars - it would add to the federal deficit! While that is entirely correct, it is quite conceivable that other large departmental budgets such as defense or health and human services probably "lose" that much in a short space of time through inefficiency, fraud and waste. While the JTLA was passed by the Congress in 1986 with an authorization of $1 million, the Department of Commerce where the Office would be located had to find the necessary $1 million from within its appropriated budget. It took the Administration almost a year to set up the Office and select the one full time person (Sabina Javits) and part-time consultant (T. Kusuda) for this office; the Office's budget of $300,000 for the first year was assembled from several sources, the largest contributor of which was the National Bureau of Standards.

The objectives of this Office are to:

- monitor Japanese technical activities and developments
- consult with businesses, professional societies and libraries in the U.S. regarding their needs for information on Japanese developments in technology and engineering
- coordinate with other agencies and departments of the Federal Government to identify significant gaps and avoid duplication in efforts by the Federal government to acquire, translate, index and disseminate Japanese technical information
- prepare annual reports regarding important Japanese scientific discoveries and technical innovations in such areas as computers, semiconductors, biotechnology,and robotics and manufacturing.
- encourage professional societies and private businesses in the U.S. to increase their efforts to acquire, screen, translate and disseminate Japanese literature
- publish an annual directory of resources in the U.S. which translate, abstract and disseminate Japanese technical literature.

This is a hefty assignment for an Office with modest budget and personnel allowances. While the creation of this Office with such a limited budget at such a measured pace with such less than enthusiastic support from the Administration can only be described as a feeble response to a major challenge in high technology.

Nevertheless, the one full time person and part time consultant have made a valiant attempt to rise to the occasion: they have tried to reach and convince the private sector about its mission and the S&T challenge it faces from Japan. It has sponsored conferences, e.g. on machine translation, it has begun issuing a periodic report on S&T exchange. No amount of enthusiasm can overcome a budgetary handicap, or a not too enthusiastic Departmental leadership (as viewed by this writer). Despite it's symbolic presence at Departmental headquarters there are yet movements to transfer it to the National Technical Information

Services in Springfield, VA.

If the U.S. is serious about responding to the Japanese Challenge, perhaps this Office, only as a beginning, should be expanded and placed immediately under the Under Secretary for the newly created Technology Administration as an "operational-staff office". This would provide a genuinely high profile in the Department for this subject matter; it would hopefully provide a message, send a signal to the private sector about the seriousness of the Japanese Challenge and provide positive feedback to the Congress, the creator of the Office. An "operational-staff office" from the point of view of proper demarcation of line and staff function is an anomaly. We are faced with a situation that requires special action. This office should be an adviser to the Under Secretary for S&T and at the same time would be involved in certain kinds of operational matters such as managing conferences.

The creation of this ever so modest Office surely does not give the impression - to the Japanese or anyone else - of a vigorous, determined, effort; it is one that gives the impression that the U.S. is only very modestly serious about the Japanese Challenge.

**2. Technology transfer legislation and agreements**

Toward the end of the 1970s, there was a growing sentiment that a large amount of patentable research had been done in Federal laboratories and also through the use of federal R&D funds by contractors but because no one had by law exclusive right to develop the ideas and results of this research, they apparently lay fallow and were ignored. There was a lingering anxiety that this research much of which could be purchased through the afore-mentioned NTIS at a low cost could be developed commercially by foreigners (including, of course, the Japanese). The legal concept behind this openness was that research results stemming from the use of taxes should be open to whomever wishes to exploit this material. This writer has not been able to find any systematic study showing that foreigners - or for that matter U.S. citizens - have exceptionally exploited these research results; only anecdotal information exists on how, if at all, foreigners successfully exploited these research results. And even then, these examples are few and far between.

A series of laws were passed by the Congress beginning in 1980 and culminating in 1986 with the enactment of the Technology Transfer Act. One of the main features of these series of laws is that they permit federal laboratories to enter into agreements with universities and non-profit research institutions for the latter to hold exclusive rights to exploit commercially the results of their research done under contract to a federal laboratory. The government would continue to hold the patent and be able to purchase products based on this patent without paying royalty. Another important aspect of this legislation with international ramifications was that directors of federal laboratories could exclude foreigners from these laboratories if the corresponding laboratories in that foreigners home country do not maintain an open access to U.S. scientists and engineers. In April 1987, the Administration issued an executive order (#02591) in response to this legislation, part of which stipulated that intellectual property rights would hereafter be required to be included in future S&T agreements.

This legislation has been mentioned not because it has a direct bearing on the U.S.-Japan S&T relationship, but because it stems from a growing anxiety about the state of U.S. S&T research and development in the world today, including our competitive position vis-a-vis the Japanese. It is mentioned here because the possible use of the veto authority given to the directors of the federal laboratories was hinted at during the 1987-88 negotiations with Japan for a new S&T agreement, if such an agreement was not forthcoming. Intellectual property rights mentioned in the executive order were incorporated for the first time into the 1988 U.S-Japan S&T agreement, presumably as a model for future such agreements with other countries.

After apparently agonizing soul-searching by the Japanese Government, Japan signed an

agreement on the transfer of military technology to the U.S. in December 1983 at the behest of the U.S. government.

The U.S. and Japan also concluded an agreement on Japan's participation in research related to the Strategic Defense Initiative in 1987.

The agreement concerning the implementation procedures for the 1956 Defense Secrecy Agreement (formally known as the Agreement to facilitate interchange of patent rights and technical information for defense purposes) were signed after 32 years on April 12, 1988. It concerns the handling of classified military technology between the two countries.

The 1988 U.S.-Japan Science and Technology Cooperation Agreement signed on June 20 signed by President Reagan and Prime Minister Takeshita created a new era in S&T relations between the two countries. It created a new management structure to govern these relations and stipulated in unusual detail how intellectual property rights would be handled.

These agreements are all manifestations of the drastically changed relationships in S&T between the two countries. It would seem that they would be or should be taken with the utmost seriousness by the U.S. S&T community in the government, academia, and industry as symbolic of the urgent need to organize thoroughly the necessary resources to monitor systematically and continuously JSTI. No resounding demand has been detected for this purpose in the halls of Congress. in the Executive, in academia or by industry.

**D. Educational Activities**

One of the major barriers to greater understanding, appreciation, and utilization of JSTI that is always mentioned is the lack of mastery of the Japanese language by U.S. scientists and engineers. A number of universities, recognized the need for a knowledge of technical Japanese, created special language programs for engineers. New York University began a Japanese language program for majors in computer science in 1982. MIT began a special language program in 1981 for engineers wishing to study in Japan. North Carolina State University also has a Japanese language program for science and engineering students. The Engineering Department of the University of Wisconsin at Madison is teaching the language with a specially prepared textbook on technical Japanese. The University of California (San Diego) also has a specialized language program. With the support of the NSF, ten universities met at MIT in November 1987 to assess what next steps government, academia and industry should do to increase the pool of scientists proficient in technical Japanese.

These are valiant efforts being carried out without the assistance of federal support. While they are worthy attempts to rectify a major deficiency in U.S. preparedness to handle the Japanese challenge, it can make only a small contribution to the much larger need for scientists and engineers who can handle Japanese language. Their efforts should be lauded and encouraged to expand their programs to the greatest extent possible. If this language training is a major national need for the foreseeable future, should not the U.S., universities and industry, make a major joint investment in this endeavor.

For almost three decades, the NSF has had bilateral science and engineering exchange programs. In addition to these programs, in 1988 it began a "Japan Initiative" to encourage and increase investigators to conduct research in Japan for six months or more at university, government or private laboratories, to study the Japanese language and fund survey teams. Over 30 U.S. researchers could study in Japan under this program. In addition, the Japanese Government has provided almost $5 million to NSF for up to 100 Americans to do research at Japanese laboratories. The Japan Society for the Promotion of Science offers annually 50 post-doctoral awards also to study at laboratories at universities or institutions affiliated with the Ministry of Education. The Science and Technology Agency also provides for 50 possibilities

for American researchers at national laboratories. The Japanese government is supporting a total of 200 research opportunities.

**E. Marketing of Japanese S&T Information**

From the beginning of the debate about the responses to the Japanese challenge, one of the proposed principal solutions has been to rely on "the market" to supply the JSTI felt to be needed by all concerned. If there was no demand the endeavor would fail "proving" that perhaps there is little of value in JSTI. Both U.S. and Japanese institutions have been trying to provide the necessary JSTI. Generally speaking, the cost of these services are high. There does not appear to be an overwhelming success rate among the providers. For example, the Japanese Technical Information Research Service at the George Mason University in northern Virginia, and the University Microfilms International, Inc in Michigan have given up the ghost. It is ironic that a new corporation, CIBER, Inc in Washington, DC, 50% of which is owned by Fuji-Xerox of Japan and almost wholly financed by this firm, plans to start providing JSTI data bases in Japanese and English in Fall 1989, even in the face of apparent disinterest and corporate failures. CIBER is also preparing a report (May 1989) for the U.S. Department of Commerce on accessing JSTI data bases running in Japan in Japanese and English. In order for this service to be a success, the consumer must believe he needs the information for his survival, believes it is worth the cost, and that there is Japanese information that needs to be obtained, studied, assessed, and utilized. It is not yet clear that the consumer - the scientist and engineer - is convinced about the need for JSTI.

The National Technical Information Service (NTIS) in the U.S. Department of Commerce has been selling worldwide technical information obtained in the main from U.S. federal laboratories. In the early 1980s, NTIS employed a retired Japanese banker who worked in conjunction with Mitsubishi Research Institute, NTIS's sales agent in Tokyo, to increase NTIS holdings of Japanese technical information which it could, in turn, sell to interested American (and others too) institutions and individuals of all kinds. According to NTIS, it had acquired about 10,000 items of Japanese origin between 1980 and 1985. During this period it sold about 20,000 copies, approximately 2 copies per title. Since 1985 it has another 3,500 items, making a total of 13,500 items; during this period it sold about 53,000 copies, approximately 4 copies per title, double the earlier period. It should be noted, however, about half of the titles are in English.

When the U.S. was confronted with the Soviet Sputnik, it was confronted with a tangible, specific and concrete object, which could clearly be understood. There is no such symbolic clear cut Japanese example to which to point. The U.S. government supported for a number of years, a special effort to translate Soviet periodicals, books in science and technology. It has been suggested that a similar effort should be launched in covering JSTI, except that in this case substantial budgetary support would be necessary (a difficult achievement in these days of budgetary deficits), and the legal complications of copyrights connected with the Japanese books and articles to be translated.

Again, if the Japanese challenge is real and serious and the U.S. as a nation needs to to make a coordinated and systematic, serious and continuous effort to meet this challenge, is it not appropriate to seriously consider the creation of a jointly (government and private sector) operated translation center which could be weaned from subsidies within five years. If it could not be made an on-going operation within this period, then perhaps this line of endeavor should be abandoned.

In Fall 1987, Dr. Christopher Hill of the Congressional Reference Service, made the only known effort to put a price tag on the cost of carrying out programs of access to JSTI. The study was made in the first instance at the request of Senator John D. Rockefeller. Let us accept his assumptions and pricing calculations for the moment. One of his options for a JSTI

*dissemination program in the U.S. would cost about $23-25 million, 0.04% of total federal funds* for all R&D of over $60 billion in 1987 (Japanese Technical Information: Opportunities to improve U.S. access, 87-818S, October 13, 1987, p. 53-55). He suggested that if the availability of such information were to result in obviating the need to carry out as little as 0.15% of the total U.S. basic research (now costing a total of $15 billion/year or 0.02% of total U.S. research and development it would be cost-effective for the U.S. While one could challenge and argue about the assumptions and calculations leading to the above conclusions, the proposition is provocative - but to the best of my knowledge was never seriously considered.

**F. Institutional Developments**

One of the institutional developments has been described under legislative action with the creation of the Office of Japanese Technical Literature in the Department of Commerce. Another partial institutional development is the NTIS arrangement in Tokyo described above to garner more materials from Tokyo.

The Semiconductor Industry Association and the American Electronic Association jointly have sponsored a representative in Tokyo since 1986. He was funded by U.S. industry with an initial contribution from the International Trade Administration, the U.S. Department of COmmerce. It is probably too early to assess the efficacy of this representation in Tokyo and also quite difficult to accomplish from Washington, DC.

The National Academy of Sciences in Washington, DC, belatedly created a new Office of Japan Affairs in March 1988. The motivation and felt need for the Japan Office was probably greatly fostered by the afore-mentioned U.S.-Japan high level S&T conferences held in 1985 and 1986. The functions and responsibilities of this office are to provide a resource to the NAS complex and the U.S. S&T community on JSTI, promote better working relations related to S&T policy between the two countries.

While an initial seed funding was provided for this Office, its future viability depends on obtaining contracts from various government agencies or finding the funds to carry out U.S.-Japan S&T related research projects. It has sponsored workshops on comparing the culture of scientific research in the United States and Japan. It is also expected that this Office will organize a meeting to assess the state-of-the-art of machine translation and the situation in the U.S. as a prelude to creating a national plan of action (and budget) for MT in the U.S. Since this Office has only recently been created and is now planning its agenda for the future, an assessment must be postponed.

The Microelectronics and Computer Technology Corporation (MCC) created in 1983, the Semiconductor Research Consortium (SRC) and SEMATECH, and the more recently (Jan 12, 1989) declared intention of 17 U.S. firms to develop jointly an American alternative to the Japanese and European HDTV (High definition TV). These are, for the U.S., new cooperative industry research programs among competing firms created partially in response to the Japanese Challenge.

MCC was initially created in response to the Japanese fifth generation computer project. It has a membership of 19 companies who contribute to the annual budget of about $65-70 million. One of its founding principles had been not to solicit government contracts; it broke this rule in 1988 with a DARPA project in 1988. Over the years, about a third of the shareholders have changed. Several shareholders have announced that they were incorporating technology developed by MCC in their operations. MCC has been awarded 11 patents and has 50 pending. Since the success of MCC rests with the continuous and effective transfer of technology to its shareholders, it seems to have partially accomplished its mission during the past five years, a very short time indeed for such success.

DOD's DARPA committed $30 million to assist in the development of an American high definition TV the creation of which it is asserted would be crucial to future U.S. competitiveness in electronics and computers (Washington Post 3/6/89). Among the bidders on these contracts are U.S. subsidiaries of Netherlands and Japanese electronic giants, Philips and Sony, respectively. DOD says it is willing to give contracts to these subsidiaries, Secretary of Commerce Robert Mosbacher is opposed. Since the U.S. has, in the past, demanded that U.S. subsidiaries in Japan be given equal treatment as Japanese firms, it would seem to be rather inconsistent now to exclude foreign subsidiaries in the U.S. from such contracts.

A more explicit statement about the Japanese Challenge could not be made when these organizations were created and the DOD financial commitment was announced.

**G. Library Collections.**

One of the earliest references in this essay was the recommendation in the 1979 GM Research Library report to improve Library collections. The adequacy of U.S. libraries in collecting an adequate representative series of S&T journals was often debated in the several workshops in the early 1980s. In recent years the apparent urgency of this matter has faded and disappeared into the background. At the time, representatives of several specialized libraries attended these workshops and explained their situations. It was then, and presumably still, not clear whether these and other libraries have an adequate collection to respond to the needs of the U.S. S&T community. It was recommended at the time that a survey be conducted to ascertain those needs and to see whether the libraries have the resources and can provide the services from a properly stocked collection of representative Japanese S&T journals. To the best of my knowledge this was never accomplished. It should be pointed out that the Library of Congress (LC) has a sizeable collection of S&T journals in Japanese even though it subscribes to less than 10% (86) of a list of 955 titles (based on Faxon's Periodicals in Japan) and has an incomplete collection of 347 other S&T journals which are obtained on an exchange, gift or transfer basis. Again, it is not clear whether the most needed and appropriate S&T journals are being collected. This writer was informed that LC receives 20-25 requests daily for copies of materials from its collection of Japanese S&T journals. While this volume - and it is slowly increasing - keeps the appropriate Library staff occupied, it seem to be a reflection of the present lack of a critical mass to make an enterprise commercially viable in this area. Since professional journals provide one of the fundamental bases for keeping track and gauging the accomplishments of Japanese S&T, it would seem highly appropriate and necessary for the Department of Commerce in conjunction with the National Science Foundation to conduct this survey - its never too late.

**H. Evaluations of Japanese S&T**

This is one area where considerable time, effort, money and manpower have been expended to obtain an assessment of the level, sophistication, direction, and relative standing of Japanese science and technology in relation of that of the U.S. Since 1979 there have been a whole range of such assessments of specific technical areas. This is probably the first serious in-depth evaluation of Japanese S&T. The following list of studies by year and subject will provide the range, scope and breadth of these assessments:

| | |
|---|---|
| 1982 | International Developments in Computers (NRC) |
| 1983 | Satellite & Rocket Technology (J. Bloom) |
| 1984 | Commercial Biotechnology, an international analysis (OTA) |
| | Computer Science (JTech) |
| | High Technology Ceramics (NRC) |

| | |
|---|---|
| 1985 | Robotics (Yamaichi Securities)<br>Mechatronics (JTech)<br>Biotechnology (JTech)<br>Biotechnology (NSF)<br>Opto & Micro-Electronics (JTech)<br>Electro-Optics Millimeter/Microwave Technology (DOD) |
| 1986 | Telecommunications (JTech)<br>Advanced Materials (JTech)<br>Advanced Processing of Electronic Materials (NRC)<br>Japanese Opto Electronics Industry and its relationship to the Strategic Defense Initiative (H. Glazer) |
| 1987 | Advanced Computing (JTech)<br>Defense Semiconductor Dependency (DOD)<br>Ceramics and Semiconductor Sciences (Commerce)<br>Electro-Optics and Millimeter Wave Technology (DOD) |
| 1988 | Computer Integrated Manufacturing and Computer Assisted Design for the Semiconductor Industry in Japan (JTech)<br>Advanced ceramics (NAS)<br>Commercializing High-Temperature Superconductivity (OTA)<br>ERATO Program (JTech)<br>Defense Industrial & Technology Base (DOD)<br>Military Systems Applications of Superconductors (DOD) |
| 1989 | Advanced Sensors (JTech) |

In general the above reports present an exceedingly challenging array of Japanese scientific and technical achievements which the U.S. can ignore only at its own peril. Among the above studies, the most systematically conducted studies are those marked JTech. They were funded by the Department of Commerce in the Phase I of three studies; later, Phase II and III were funded by NSF and the Defense Advanced Research Projects Agency, Department of Defense (DARPA, DOD). The first six studies have been published in hardcover by Ballinger Publishing Co under Gaining Ground (1988). Each panel consisted of Americans expert in their fields. These teams provided an assessment by comparing U.S. and Japanese efforts, by visiting and identifying key Japanese researchers, R&D organizations and other resources, analyzing public literature and comparing similar programs for Europe. Workshops were held to report each teams findings. Final reports were subsequently prepared, fairly widely circulated and made available through NTIS.

At one of the workshops attended by this writer, the team leader quipped that all those attending this workshop will, in all probability, diligently read the final report but after that it will be filed and basically forgotten - except that the diligent Japanese will naturally obtain a copy, study it in evening committee sessions and reach a consensus on what next to do about their noted shortcomings. Indeed, a sad commentary on the seriousness with which the greater part of the U.S. scientific community take the Japanese Challenge.

Although not a direct assessment of Japanese S&T, there are other developments and activities which provide an implied assessment. For example, the Magnetic Society of the IEEE and the American Society of Rheology translate their Japanese counterpart journals into English, chemical and medical abstracts on Japanese R&D are systematically published.

In additional to the above studies, references have appeared in the literature to government studies assessing where the U.S. stands in defense related technologies, e.g. an National Security Council study on the "Chip War" rated the U.S. behind in 14 of 26 different fronts, even in 6,

and ahead in 6 (Wall St. Journal, 11/14/88).

Although somewhat dated, the report (June 1984) of the Defense Science Board (DSB) Task Force on Industry-to-Industry International Armaments Cooperation, Phase II on Japan should be mentioned since it analyzed the U.S.-Japan relationship in the context of the military technology. Its first finding was that "A cohesive overall strategy with respect to Japan does not exist and is urgently needed" (p. iii). It concluded that it would be possible through dual-use technology provided by Japan to create a two-way flow of technology, and that Japan would have the potential to become a major competitor in defense technology and products as a result of achieving its high priority national goal of "basic technological innovation" (p. iv). Its recommendations included ideas that the U.S. broaden, judiciously and reciprocally, its technological cooperation with Japan, encourage industry-to-industry cooperation for this purpose, accelerate the translation of Japanese technical and scientific literature, create programs to accelerate the exchange of scientists and engineers, and periodically assess the status and momentum of Japanese technologies and a high priority comprehensive study on overall trade/defense/economic trade-offs and strategy for Japan to provide a broader policy context for technological cooperation. It is not clear whether any or all of these and other recommendations have been carried out. The DSB also issued two other reports on defense semiconductor dependency (1987) and a two-volume study on defense industry and technology base both of which comments on Japan. The former report has stirred debate and raised anxieties about the implications of a growing dependency on even as close an ally as Japan - in the narrower context of military security, not necessarily in the broader context of the overall U.S. S&T posture.

## I. Technical Developments

The only technical development of substantive interest here is machine translation. A "machine translation summit" was held in Tokyo in Fall 1987. The next such meeting will be held in Germany in Fall 1989. Why not the U.S.? Apparently the U.S. is doing so little in this field that it does not rate a spot on the MT map! The leader in MT is Japan. Several Japanese companies have reached the point where simple sentences can be translated by machine with fair accuracy but the capability must still be greatly refined and advanced before a reliable machine can be produced.

The U.S. non-role at this time seems still to be in the shadows of the ghost of the now famous ALPAC report on MT (Automatic Language Processing Advisory Committee) from the 1960s which because of the capabilities then existing concluded pessimistically about the future of MT. Since then, of course, computer capabilities have so progressed that now MT possibilities are no longer just a dream.

Despite valiant attempts to teach more Americans the Japanese language, the avalanche of information will be overwhelming. If we are to keep up with the flow of technical and scientific information from worldwide sources, our coverage, appreciation, digestion of this data must be aided by MT. The Japanese, with a much better command of English than we have or possibly will ever have of Japanese, have placed a high priority on MT for their manipulation, coverage, digestion and utilization of this flow of data in the twenty-first century. Surely we need such a capability even more than the Japanese.

The U.S. Air Force is funding a contract for the development of the Systran system. While this system was initially developed in the U.S., it was purchased by a Japanese firm. It is hoped that a useful capability in Japanese-English translation will be developed. The contract, however, restricts the use of the results to U.S. Government agencies. Ultimately for the improved competitive position of U.S. industry, MT must be made available to both government and industry. A detailed report is given on MT in an appendix to the Report to Congress, by the Office of Japanese Technical Literature in 1988.

In an attempt to expedite the development of an MT capability in the U.S., Congressman Doug Walgren of Pittsburgh in April 1988 called for a national assessment of MT, a plan of action with a budget to achieve a modest domestic goal within, for example, the next five years. It appears that the conference for the national assessment will take place no earlier than Fall 1989 with a budget plan for FY1992. In the meantime, such Japanese firms as Oki, Fujitsu, Hitachi, NEC, Sanyo, Sharp, Toshiba and Mitsubishi are steaming ahead with improving their MT computer software.

**J. Surveys of JSTI Utilization**

To the best of my knowledge, only one survey has been completed on how U.S. institutions utilize JSTI. Furthermore, it is an interesting commentary on the U.S. response to the Japanese S&T challenge that the first such survey was carried out in late 1987 and completed in early 1988. A 15-page questionnaire was sent to 100 institutions involved in advanced ceramics R&D: 36 large companies, 35 small and medium companies, 13 universities, 11 national laboratories and FFRDCs (federally funded R&D corporations), and 5 non-profit institutes). The response rate for the latter two groups was 100%, for the others, 64, 71 and 85%, respectively. Since advanced ceramics is a field where the Japanese are at least abreast of U.S. technology if not ahead in some instances, it is useful to see how Americans in this field are looking upon their principal competitors.

The survey report was divided into two parts, those with Japanese information programs and those with no programs. While there are naturally differences in these two groups a few general conclusions are listed below. For additional details refer to Survey of Supply/Demand Relationships for Japanese Technical Information in the U.S.: The field of advanced ceramics R&D, NTIS, U.S. Department. 1988).

The overall conclusion of the study was that the while the American institutions claimed they were aware of Japanese developments and progress, most of them do not devote a great amount of special attention to collecting, analyzing and integrating technical information from Japanese sources (Above survey report, p. 28). This is uncomfortably similar to one of the findings in a 1982 study on international computer science which stated that even when materials were written in English, little attention is paid by U.S. researchers and engineers to developments in Japanese computer science - perhaps this has changed substantially in the past seven years.

Professional journals, business or trade publications, specialized abstract services and U.S. patent literature appear to be primarily sources of information on Japanese developments. Translated abstracts appear to be of the greatest value. The obstacles to obtaining Japanese information appeared to center on the oft-repeated lack of language capability, slowness and prohibitive costs of translations, and some Japanese reluctance to share data. Another problem mentioned was the short-term U.S. corporate planning span, which most respondents did not think would change much in the near future. Many respondents felt that there should be much larger allocation of resources to make possible more opportunities for U.S. and Japanese scientists and engineers to have person-to-person contacts as an effective means for the effective and continuous exchange of information across the Pacific.

In regards to an assessment of the standing of Japanese advanced ceramics vis-a-vis the U.S. at this time and in the future (ten years hence), the overall estimate was that the Japanese would be equal or greater in strength than the U.S. In a way it is ironic that large companies and FFRDCs without Japanese information programs feel that the U.S. will fare better in the future.

Who should take the lead in acquiring and disseminating JSTI in the U.S.? The feeling among

those with Japanese information programs were evenly split between the need for government or the private sector taking the lead. The government sector was slightly more favored as the one to take the lead among those with no such programs.

Under "Observations" the report made the following comments which impinge upon the basic concern of this paper:

> If the United States is to embark on a concerted and well-planned effort to insure that the research and development activities of the nation are coordinated between and within the public and private sectors, effective means for the dissemination of technical information are imperative. The problem is compounded when foreign sources of information are as valuable as indigenous sources. This survey has demonstrated that in the relatively small field of advanced ceramics, there is no single system at the national level that can serve to furnish information about the number, identification and degree of involvement of organizations that would qualify as recipients of valuable technical information (p.26).

**K. Conclusion**

Based on the above, an impressive array of activities have been launched with great expectations and determination. It is clear a considerable amount of energy has been expended to try to persuade the "relevant publics" that the Japanese S&T Challenge to the U.S. must be taken seriously and a fairly substantial effort has been made on how to mobilize and focus U.S. sentiment, energies, manpower, resources, and determination to meet this Challenge head-on.

Numerous worthwhile technical assessments, such as the continuing JTech studies, have been made showing rather conclusively that Japanese S&T is at a world-class level and steaming ahead. Unfortunately, these results and the implications for U.S. S&T do not appear to be have been sufficiently well publicized, have not reached enough people, thus are not fully appreciated.

There have been a wide variety of efforts ranging from seminars, symposia, legislation, reports, surveys, and technical assessments. Most of the consciousness raising activities seem to have originated from academicians, consultants, government officials. These efforts cannot be said to be in any way coordinated; in fact, they are definitely disjointed and super modest.

In contrast, there is no evidence that private sector pushed for any sort of programmatic response to the Japanese Challenge which would transcend the particular interests of a companies, industry, or technical field.

Similarly, it is equally clear that neither the U.S. Congress nor the Executive Branch have apparently felt sufficiently moved to provide concerted and continuing leadership to mobilize a national response to the Japanese Challenge. If the Japanese Challenge is real and demands a responsible response, then based on the above survey, there is no single system and it appears no determined interest at the national level that can serve to provide the leadership with a concerted and well-planned effort to assure that there is an effective means for the dissemination of technical information throughout the U.S. S&T establishment.

Recommendations on what to do in the future are numerous but few in retrospect have been seriously considered by the government or by industry - at least there is little evidence to this effect - let alone actually carried out. Even the very modest Japanese Technical Literature Act was somewhat forcibly created by the Congress with no new appropriated funds. The Congress itself does not steadily focus on the JSTI issue and how to respond to the Challenge and does not try to keep track of Japanese S&T developments for its own edification through such a mechanism as even a part-time consultant.

Perhaps, if we believe in the reality of the Challenge, it might be useful to resurrect and reassess the estimated costs of a JSTI program in the U.S. (mentioned above in Dr. Hill's study) to see whether a coordinated program could be truly cost-effective.

Perhaps, on the other hand, the Japanese Challenge is too amorphous, too abstract, lacking a critical mass, in its present phase to be fully appreciated for a coordinated response to be launched, except that the results of a tardy, incorrect, inadequate response could result in concrete losses for the U.S. in its S&T world leadership.

The issue is rather well stated in a recent review of a book by James Fallows, More Like Us: Making America Great Again. The reviewer, Jonathan Yardley, concluded that

> The problem isn't with Fallows' analysis, which is as useful as it is acute, but with the American people and their system. We've allowed ourselves to become static, if not indeed ossified, and in the bargain we've turned selfish - too selfish, probably to respond with generosity and unity to anything except clear unavoidable national emergencies. Yes, what Fallows is writing about probably is precisely such an emergency [not JSTI, of course, but an entire U.S. societal issue]; but it isn't clear enough to shake us out of our complacency. (Washington Post, 3/5/89. Book World p. 3).

Perhaps, the reason for this lack of determined national leadership in providing a clear response stems from the divided attitude found in the above mentioned survey and also perhaps lies in the very heart of the pluralistic system under which the U.S. operates.

In recent testimony (March 1, 1989) on S&T priorities for the U.S. before the House Subcommittee on Science, Research and Technology, Dr. George A. Keyworth, former science adviser to President Reagan, made the following judgment:

> What's not working right is the culture: A culture in academe that often see capitalism as counter-creative; A culture in government that sees business as threatening its prerogatives; and a culture in business that is skeptical of both government and universities. Until this set of adversarial relationships is reversed, to the way it was in Vannevar Bush's postwar time, no amount of attention to funding priorities will achieve the desired objective - using science and technology better to preserve our way of life.

Perhaps, conventional wisdom has for the moment made its decision that the Japanese Challenge is not a clear and present Challenge which requires an appropriate systematic, concerted, continuing response.

Perhaps, we, the U.S., are - to use a golfing metaphor - in a sand trap. Is there no one, either in the Congress or in the Executive, even perhaps in the Private Sector sufficiently motivated and determined to take the necessary action, hit the ball and lead the U.S. out of this sand trap?

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National Association
of Manufacturers

HOWARD LEWIS, III
Vice President
International Economic Affairs

June 22, 1989

The Honorable Doug Walgren
Chairman, Subcommittee on Science,
Research and Technology
Committee on Science, Space and Technology
2319 Rayburn House Office Building
Washington, D.C. 20515

Dear Mr. Walgren:

Members of the National Association of Manufacturers face a problem of having their exports closed out of foreign markets because they do not comply with foreign certification or standards requirements. It is bad enough when this happens because a foreign nation is specifically trying to erect trade barriers to American products. It is even worse when this happens because the United States fails to respond to a request for help from another nation in developing their national certification and standards policies.

This is exactly the situation that the United States now confronts. Nearly a dozen nations have asked the United States for assistance in developing technical standards for many of their products. Japan, West Germany, Great Britain and others are actively engaged in providing assistance. The U.S. Government has responded to such requests, however, by saying it does not have the resources to provide such assistance either through the National Institute of Standards and Technology (NIST) or other federal agencies.

Yet, the Trade Act of 1988 states that a function of NIST is to "cooperate...with the governments of other nations and international organizations...in establishing standard practices, codes, specifications, and voluntary consensus standards." This law represents three years of hard work to improve U.S. trade policies. The United States must now follow through not only in terms of market access but also in terms of taking the necessary steps to support U.S. exports.

For this reason, the NAM supports the approach taken in Rep. Dymally's bill, H.R. 2468. The association believes responding to requests for assistance is a meaningful way the U.S. Government can promote U.S. exports and that such assistance can be coordinated and funded by the U.S. Government. The attached memorandum on U.S. export policies (specifically pages 7-8) more fully explains the issue.

The NAM therefore encourages you to support H.R. 2468 when you are considering the 1990 authorization for NIST. Thank you for your consideration of this matter. I would be pleased to discuss this or any other issue raised in the attached memorandum with you at your convenience.

Sincerely,

Enclosure

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June 13, 1989

MEMORANDUM

**Subject:** **A U.S. Export Drive**

**By:** Howard Lewis III, Vice President-International Economic Affairs
National Association of Manufacturers

Overview

Americans have heard a lot about export-led growth in other nations such as Japan, Germany, South Korea and Taiwan. For the past two years, however, it has been the United States' turn to experience this type of growth. In 1987, exports directly accounted for 30% of U.S. economic expansion and for nearly 40% in the past year.[1] Working with latest available date, a new Commerce Department study found that in 1986 4.6 million jobs in this country depend upon exports.[2] This figure is undoubtedly even higher today given export growth in 1987 and 1988.

While these numbers are encouraging, now is not the time for complacency over the continuation of U.S. export growth. In 1989, U.S. exports are expected to increase by only 15% compared to the 23% expansion seen in 1988.[3] A recent poll of executives on NAM's Board of Directors found that 44% expected their exports to increase this year, 54% expected them to remain about the same and 2% anticipated a drop. It is clear that much of U.S. export growth resulted from the realignment of the dollar since 1985, with little coming from a concerted U.S. export drive. And, the big boost from the dollar may have run its course. That is why the United States should be looking for ways to launch a major drive to keep the current export boom going (some examples of the elements in such a drive can be found on page 2).

Supporting U.S. exports makes sense. It fits with the need to shift the U.S. economy towards increased investment, savings and overseas markets and away from domestic consumption and government spending. It provides a boost to the most competitive sectors of our economy spending. It is a logical and necessary follow-on to the market opening initiatives mandated in the 1988 Omnibus Trade and Competitiveness Act.

We should not underestimate the contribution which continued export growth can make in reducing the U.S. trade deficit. Paul McCracken, former Chairman of the Council of Economic Advisors, goes so far as to argue in a recent Wall Street Journal editorial that "the key to the U.S. trade problem is not bloated imports but weak exports. Even in 1988, after a sharp recovery, exports were only 6.6% of U.S. output,

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## ELEMENTS OF AN EXPORT DRIVE

| ISSUE | IMPACT ON TRADE/EXPORTS | POLICY RECOMMENDATIONS |
|---|---|---|
| *EXIMBANK:* Cuts in Exim direct loan budget of 85% since 1981 have left U.S. in a weak position to counter other official finance programs. | OECD nations still offering **$7-9 billion** yearly in direct credits while great uncertainty exists over financing U.S. direct loan budget. | Maintain Exim direct loan budget at current levels, use guarantee program to rejuvenate commercial financing, establish appropriate treatment of Exim in overall federal budget. |
| *TIED AID/MIXED CREDITS:* Other Industrial nations are offering mixed credits/tied aid (i.e., combination of foreign aid and official export financing) to gain strategic positions in key markets. | Mixed credit/tied aid offers in the neighbor-hood of **$15 billion** annually. | Provide greater support for capital goods projects under U.S. foreign aid and implement a credible mixed credit program. |
| *EXPORT PROMOTION:* U.S. Foreign Commercial Service (FCS) needs to be strengthened to match programs of other nations. | U.S. spends **.50 cents** per capita on export promotion versus **$2.00** in West Germany, **$4.00** in France, **$5.00** in Japan, and nearly **$8.00** in Canada. | Provide greater resources for FCS and address serious management and morale problems found in recent GAO report. |
| *PRODUCT STANDARDS:* U.S. has not acted on requests from Saudi Arabia, China, Brazil, India and five other nations for assistance in development of product standards. Other nations have responded to requests. | Harmonization of standards by Saudi Arabia and other nations in the Gulf region alone could increase U.S. export by **$100-300 million.** | Establish program in Commerce Department to respond to these requests for development of product standards. |
| *TAXATION OF EXPORT INCOME:* Until recently, Treasury Department has proposed changes which would increase the tax on income earned by U.S. manufacturers exporting to overseas affiliates. | Current regulations contribute as much as **$5 billion** annually in exports to U.S. trade and generate **170,000 jobs.** | Abandon any further attempts at such changes. |
| *EXPORT DISINCENTIVES:* Largest disincentive is probably U.S. export control system on so-called "dual use" commercial products. | National Academy of Science estimated that **$9 billion** in exports lost each year due to cumbersome system that requires **40% manufactured exports** get prior approval before leaving U.S. | Implement 1988 Trade bill provisions to reduce licensing requirements, scope of control list, limit unilateral controls and decontrol low tech exports. |

compared with just over 8% in 1980."[4] He maintains that "further sustained and large improvement in our external trade is not apt to occur unless U.S. businesses become hungrier for export orders. And the origin of that must be less expansive domestic monetary and fiscal policies."[5]

To some extent, the lack of prominence given to U.S. export policies may be due to the widespread view that exporting, at least by itself, does not represent a viable corporate strategy for competing in today's highly interdependent, global market. Indeed, investment in overseas plants and facilities has become a cornerstone in the overall competitive strategy of many U.S. multinational firms. Exports however, still play a central role in this strategy as evidenced by the fact that shipments between American parents and their foreign affiliates account for 30% of total U.S. exports. Moreover, exports undoubtedly will play a larger role in the competitive strategies of many medium-sized U.S. firms. In order to achieve greater economies of scale in their domestic production, these firms must seek out markets on an international rather than domestic scale. This phenomenon is already seen among medium-sized, high technology firms in this country which typically export between 30 to 40 pecent of their output. In short, exporting will remain a vital part of U.S. corporate strategy for competing in today's international markets.

An export drive by itself, of course, will not eliminate U.S. trade problems. To believe that would be naive. We clearly must focus on recapturing our own domestic markets, lost to foreign competitors during the years of the high dollar, 1981-85. And we must pursue an overall program that addresses the federal budget deficit, exchange rates and the opening of foreign markets. Sound macro-policies are essential to restoring the competitiveness of U.S. industry. It is important to realize, however, that export related policies ranging from financing to taxation cannot be dismissed as relatively unimportant, peripheral matters.

Large amounts of trade are heavily influenced by these policies.[6] For example, as will be discussed below, over $5 billion in exports are generated each year by the foreign source tax rule on exports. While the Eximbank faces continued uncertainty over its direct loan program, other industrial nations offer $7-9 billion a year in direct credit export financing. Over $15 billion in mixed credit offers were made last year by our competitors--offers which the U.S. is essentially unable to counter. And, nearly $9 billion in exports may be lost because of our cumbersome export control system which requires that 40% of our manufactured exports--$60 billion in trade--get prior approval from the government before leaving the country.

The potential payoff of a U.S. export drive, therefore, could be considerable. We can be sure, however, that other major industrial nations will not easily give up the export markets they captured during the 1981-85 "super dollar" era. As exchange rate adjustments narrow the price gaps between the U.S. and our competitors, government support for exports, whether in terms of export financing, elimination of export disincentives, or aggressive overseas commercial services, will play an important role in successful efforts to compete for export business around the world.

This will be especially true in the most competitive of U.S. industrial sectors--capital goods--which accounts for 45% of U.S. manufactured exports.

Elements of an Export Drive

Examples of some immediate policy actions to encourage continued export growth include:

1. Strengthening the Eximbank: Export financing is the weak link in U.S. export expansion, with Eximbank resources totally inadequate to meet the needs of U.S. exporters. The Bank had to close its doors to new direct loan business three-quarters of the way through 1988 and is expected to shut down even earlier this year because of uncertainty over funding. Over the past nine years Eximbank's direct loan budget has been cut by 85%. Other OECD nations, however, have continued to offer significant amounts of official export financing--most recent data indicates in the neighborhood of $7-9 billion per year.[7]

American exporters will find less export financing help from commercial banks many of whom have abandoned export financing over the past decade. As noted in a 1988 report by the House Banking Subcommittee on International Finance, Trade and Monetary Policy, "exporters and U.S. leaders are heading in the opposite directions. While exporters face increased international competition and higher levels of risks--needing financing support to compete--the U.S. commercial banks have become adverse to foreign risks and are scaling down their international lending, including export financing."[8] For those U.S. banks which have maintained trade relating financing, the Subcommittee report found that over 50% was import rather than export related.[9]

In a survey of nearly 100 U.S. exporters conducted as part of the House Subcommittee report, 66% of the responding companies found that competitive export financing was only "sometimes" or "rarely available" and 53% stated that they had lost export business because of the lack of competitive financing. Almost 55% of the companies indicated that, if more export financing were available, they would export more.[10]

A strengthened Eximbank that can support a rejuvenated commercial financing sector should be the linchpin of a U.S. export drive. At a minimum, this will require maintaining Eximbank's direct loan budget at current levels. In addition, the Bank's guarantee program should be used aggressively to encourage commercial bank involvement in export financing. In the longer term, attention must be given to the treatment of the Exim in the Federal budget where Exim authorizations are counted as expenditures rather than loans repaid with interest. This deficiency significantly overstates the real impact of the Exim on the budget.

2. Trade and Aid: Closely related to official export financing offered by agencies such as Eximbank is the issue of tied aid/mixed credits in which foreign aid and official export financing are combined to achieve more attractive financing terms. As

international agreements to limit official financing practices really began to take hold in the mid-1980s, most industrial nations moved the game over to the playing field of tied aid/mixed credits, where the rules were less restrictive.

U.S. foreign assistance programs in the mid-1970s, however, had virtually abandoned the use of aid in support of capital project assistance in favor of a narrowly defined basic human needs approach to development aid. This orientation contrasts sharply with the bilateral assistance programs of other industrial nations. The extent of the difference can be seen in the following figures representing the percent of bilateral foreign aid going to capital goods projects by other donor nations:[11]

| | |
|---|---|
| Japan | 45.8% |
| Denmark | 33.0% |
| Norway | 22.5% |
| Germany | 20.8% |
| Italy | 17.0% |
| United Kingdom | 15.4% |
| Canada | 14.0% |
| Sweden | 13.3% |
| France | 13.0% |
| United States | 2.3% |

In analyzing this data, it should be remembered that Japanese bilateral foreign aid now exceeds that of the U.S.

In theory, if no link existed between the capital project assistance and the commercial interests of donor nations, we would not have to be concerned about this issue since American firms would have an equal opportunity when bidding on these projects. In practice, of course, matters are a great deal more complicated. OECD data indicates that tied aid/mixed credit offers increased from $11 billion in 1986 to over $15 billion in 1987.[12] Such credit offerings appear to have increased by approximately 400% since the early 1980s, even though various OECD agreements during this time were supposed to curb such practices.

A U.S. strategy for dealing with tied aid/mixed credits should include the following elements: 1) provide greater support for capital goods projects as a legitimate and necessary means of promoting economic development and U.S. trade interests in those nations receiving such aid (e.g., Egypt, Pakistan, Turkey); 2) further strengthen current foreign aid programs which leverage the impact of U.S. assistance. The Trade and Development Program (TDP), which supports feasibility studies and training programs, is a good example of this type of assistance; and 3) put forward and forcefully implement a credible mixed credit program which focuses on key markets in the developing world (e.g., China, India) which receive little, if any, foreign assistance and hence would not be eligible for the capital project assistance noted above.

3. Beefing up export promotions: Of the major industrial nations, the United States provides the least support in terms of export promotion and assistance. Commerce Department data indicates that the U.S. spends about 50 cents per capita on export promotion, compared to about $2.00 in West Germany, $4.00 in France, $5.00 in Japan and nearly $8.00 in Canada.[13] The U.S. has only a few more commercial officers overseas than South Korea--a nation with one-seventh the amount of trade.[14]

Besides the funding and the number of officers assigned overseas, recent reports from the General Accounting Office (GAO) and other sources have identified serious management and morale problems with the Foreign Commercial Service (FCS) and U.S. export promotion efforts. A GAO report issued in January of 1988 stated that Commerce Department export promotion efforts were plagued by "poor event selection, marketing, and recruitment and a lack of accountability for either positive results or failures." The report found that 55% of scheduled trade shows do not take place.[15] GAO staff reviewed promotion activities in four Latin American nations and found that 40% of the trade events proposed for those countries involved sectors not listed as good export opportunities in reports prepared by the foreign commercial posts.[16]

The GAO report examined the Commerce Department's Commercial Information Management Systems (CIMS) and concluded that the program may "continue to languish with only minimal capability if its technical and resource problems are not addressed by senior Commerce officials."[17] CIMS represents the third time in 10 years the Commerce Department has attempted to develop a computerized trade information system.

In the short term, the Secretary of Commerce and top policy officials in International Trade Administration should ensure that qualified career officials are appointed to top FCS jobs, that U.S. trade missions target the sectors of greatest opportunity, and that accountability exists for the running of trade events and support programs. In the longer term, however, it is clear that basic issues must be addressed in strengthening the FCS.

The 1988 Omnibus Trade and Competitiveness Act attempted to address some of these issues. Among other things, it provided statutory authority for the FCS, directed that senior Commercial Service Officers be given the rank of Minister-Counselor in eight U.S. Embassies, and assigned FCS officers to the U.S. Executive Director offices in the World Bank and other multilateral development banks (MDB) in order to promote U.S. exports in MDB procurement.

This is certainly a start at improving U.S. export promotion but a number of matters remain to be dealt with. For example, greater attention needs to be given to the coordination of U.S. commercial policies among the FCS, country desk officers, and industry specialists in the Commerce Department. Steps should be taken to ensure that the FCS has enough standing in the hierachy of American embassies to get the job done. We should examine how effectively the State Department carries out trade promotion in embassies to which no FCS officers are assigned. These are all important matters which need to be addressed in efforts to strengthen the FCS.

4. Product Standard Development: Strengthening the FCS is only part of the effort that needs to be undertaken to protect and support U.S. exports. Attention must also be focused on how the U.S. deals with actions taken by other countries that affect U.S. trade interests. While this is an extremely broad subject, a good example of what often needs to be done can be seen in recent requests the U.S. Government has received from various nations asking for assistance in the development of product standards. The quality of a product usually is not the issue here but rather regulations governing the uniformity of the size, material and performance of a product. Such regulations govern whether a product actually can be sold within a particular nation or region. This is why the standard-setting aspects of EC-92 have gained such widespread attention and concern from U.S. industry.

While the EC is not asking for official U.S. help in actually developing its standards, other nations are doing so. The U.S. Government has received such requests from Saudi Arabia, Brazil, China and six other nations. The Government maintains that it does not have the resources, either financial or technical, to assist other nations with developing such criteria. The net effect of this may be that U.S. products are being shut out of important export markets.

A case in point involves the Saudi Arabian Standards Organization (SASO). Saudi Arabia has adopted a "national standard concept" like many other industrialized nations. Under these national standards arrangements, commodities and goods that do not conform to these standards cannot enter the country. SASO also is developing import standards for the Gulf Cooperation Council, which is comprised of Saudi Arabia, Kuwait, Oman, Bahrain, Qatar and the United Arab Emirates. The Gulf Cooperation Council is the 12th largest U.S. export market, buying nearly $5 billion worth of goods in 1987. The Commerce Department estimates that with increased harmonization of standards and certification procedures for U.S. electrical, electronic and food products, U.S. exports to the Gulf Cooperation Council could potentially increase by $100-$300 million a year.[19]

In the fall of 1987, the Saudi Ministry of Commerce asked that the United States provide funding for a full-time standards expert to be assigned to SASO. The U.S. Government has responded to the Saudi request by suggesting the alternative of a privately-funded expert rather than a government official. This alternative is now being pursued.

While the United States remains uninvolved in foreign standards setting, other nations have become very actively involved. Industrialized countries including Britain, France, West Germany, Japan, Australia and New Zealand work closely with SASO staff to ensure that the standards developed do not shut their country's products out of the Saudi market. Through government-to-government agreements, these countries have technical experts at SASO and the governments pay the bills. They also educate their domestic manufacturers about SASO criteria to facilitate easy entry for their products into the country.

The situation in Saudi Arabia and SASO is an immediate problem that will be solved, if at all, with a stopgap measure. A privately-funded expert to work with SASO may be acceptable this one time, but a series of privately-funded standards experts assigned to countries around the world hardly seems to be a viable solution or the best policy in the long run. The SASO example simply points out the need for a long-term solution to the problem. Eight other nations including China, Brazil, India and Israel have already made similar requests for technical assistance in the development standards.

5. Make no further adverse changes in the taxation of export income. Over the past several years, the Treasury Department has been considering modification of the "export source rule." Under this decades-old interpretation of the nation's income tax laws, export profits generally are allocated 50% to U.S. sources and 50% to foreign sources. Throughout the period 1984-88, this rule was under attack by the Treasury, which first sought to have Congress repeal it as part of the 1986 tax reform legislation, and, when that failed, to reinterpret the rule administratively.

Treasury's attempted reinterpretation of the export source rule was vigorously opposed by NAM and other members of the Export Source Coalition. Late in 1988, Treasury relented in part, at least for the time being, and stated that exporters could continue to use the 50/50 rule except in cases where there was an "independent factory price" that could be used as the basis for allocating profits. While not entirely satisfactory, this resolution may prove adequate if it is reasonably applied by IRS auditors.

The impact of the export source rule is significant. One study, U.S. Export Competitiveness and Source-of-Income Rules, found that the current rule contributes as much as $5 billion annually in exports and generates nearly 170,000 jobs.[19] This study also concluded that the rule was particularly important in stimulating exports of high technology products by small firms. Faced with continuing large trade deficits, it simply makes no sense for U.S. tax policy to discourage exports by increasing taxes on export-related income. Treasury should abandon any further attempted changes of this sort.

6. Continue to eliminate or modify unnecessary export disincentives: The U.S. places more obstacles in the way of its exporters than any other industrial nation. Example of these export disincentives include the Foreign Corrupt Practices Act, two anti-boycott statutes, foreign policy export controls, national security export controls, and a variety of restrictive measures on organizations such as Overseas Private Investment Corporation and Eximbank which limit the ability of these agencies to support American exports. While all of these policies are intended to achieve laudatory goals, they often fly in the face of international commercial reality, ensnarling U.S. firms in red tape and extraterritorial application of U.S. laws and policies.

Changes in the Foreign Corrupt Practices Act (FCPA) contained in the 1988 Omnibus Trade and Competitiveness Act, demonstrate that it is possible to modify these export disincentives to eliminate some of the unintended impact on U.S. international commerce while at the same time maintaining the basic purpose of the statute. The recent changes in the FCPA provide a clearer guideline of what is acceptable and unacceptable behavior under the law. Their implementation will help ensure that legitimate business opportunities are not lost because of uncertainty over how the FCPA would be applied.

Perhaps the largest export disincentive facing American business today is the U.S. export control system. The National Academy of Sciences (NAS) in a 1987 study estimated nearly $9 billion in exports were lost each year because of our cumbersome export control system which requires that 40% of manufactured exports--$60 billion of commercial products--get prior approval from the U.S. Government before leaving the country.[20]

The NAS study focused on national security controls. The U.S., of course, maintains another set of controls for foreign policy reasons which have periodically embroiled the U.S. in major disputes with our allies and seriously damaged the reputation of U.S. firms as reliable suppliers. A case in point are the foreign policy controls on the export of U.S. petroleum equipment to the Soviet Union which started in 1978 and expanded in 1980-81. The Commerce Department estimated that U.S. firms lost nearly $2 billion in business before these controls were lifted in 1987.[21]

The 1988 Omnibus Trade and Competitiveness Act contained some important provisions which could:

1) significantly lessen licensing requirements for exports to the group of allies known as Cocom countries;

2) reduce the scope of the control list;

3) limit unilateral U.S. controls; and

4) decontrol low technology exports.

Implementation of these provisions over the next year will be important. In the past, progress has been stymied by inter-agency conflicts. It is vital that the leadership of top policymakers, especially in the White House, be exerted to ensure that these important reforms are carried out and that U.S. control policies are directed toward realistic and practical goals.

7. Other Actions: The preceding are some examples of policy initiatives that could be taken immediately to launch a U.S. export drive--with minimum impact on the U.S. budget. In the longer run, other steps could be taken such as continuing to promote the development of export trading companies, consolidating the two anti-boycott

statutes, and examining ways to boost U.S. trade with Eastern Europe, the Soviet Union, and China. We need to carefully review our policies towards arms exports to avoid the type of multibillion dollar loses experienced when Saudi Arabia in the mid-1980s decided to purchase British rather than U.S. military aircraft. The antitrust reforms proposed in 1988 by former Commerce Secretary Verity and former Attorney General Thornburgh have identified another major policy issue which needs to be reexamined as we look for ways to encourage greater industry collaboration on research and development.

In addition, over the longer term, we need to learn more about the very nature of U.S. exporting. This will involve answering some very basic questions. For example, what is the breakdown for the size and frequency of U.S. export transactions? Are U.S. exports generally small shipments of say $5,000 or less, or larger shipments of $25,000 or more? How many shipments does a typical U.S. exporter make in a year--200, 500, 1,000? Is there any relationship between the frequency of exporting and the size of the shipments. And how do the answers to the preceding questions vary among different industrial sectors? Only recently have we begun to develop data to answer such questions.[22] The answers may hold very important policy implications for how we should or should not go about encouraging greater U.S. exporting, especially among small/medium sized firms.

Conclusion

You cannot talk about an export drive without putting the question into the larger context of what the United States as a nation is willing to do to ensure its competitive position in international markets. The NAM has long argued that a national commitment to international competitiveness is the single most important step to be taken in developing a strategy for correcting U.S. trade problems. From this commitment flows the support necessary to implement policies that will increase our international competitiveness.

We often have paid lip service to this idea, but have done very little to adapt our policies or institutions to the new realities of international competition. Other nations have adjusted to these new realities. But in this country, government-business relations are still driven by an outdated adversarial tradition more suited to the beginning of this century rather than its end.

If the embassies or official financing institutions of other nations do a better job of supporting their commercial interests overseas, it is more a reflection of the importance they attach to international trade than it is a condemnation of our FCS or Eximbank. We cannot make the FCS or the Eximbank as good as our competitors unless we are willing to assign trade a much higher national priority than it now enjoys. In short, we get what we pay for: to date the United States has not been willing to pay the price in terms of putting aside other national priorities in order to support our international commercial interests.

## FOOTNOTES

1 "The U.S. Export Boom: Causes and Effects." Business America. U.S. Department of Commerce. October 24. 1988. p. 7-11.

2 Exports from Manufacturing Establishments. 1985 and 1986. Analytical Report Series. Bureau of the Census. U.S. Department of Commerce. 1989.

3 "Export Growth May Slow to Half of Last Year's Role". Journal of Commerce. February 9. 1989.

4 "Why U.S. Exports Are a Casualty". Wall Street Journal. March 3. 1989.

5 Ibid.

6 Sources for the figures cited in this paragraph can be found in the main body of the text.

7 Report to the U.S. Congress on Export Credit Completion. U.S. Export-Import Bank. 1988. p. 5.

8 Export Financing in the United States: Problems and Options. Committee on Banking. Finance and Urban Affairs. U.S. House of Representatives. December 1988. p. 4.

9 Ibid. p. 10

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11 Ernest H. Preeg. "Trade. Aid and Capital Projects". Washington Quarterly. Winter 1989. p. 176.

12 Statement of The Honorable John A. Bohn. President and Chairman. Export-Import Bank of the United States before the House Banking Subcommittee on International Finance. Trade and Monetary Policy. February 25. 1988. p. 19.

13 "Assistance for Exporters". Trade and Industry. National Association of Manufacturers. May 23. 1988.

14 The Commercial Services of the United States and Its Major Competitors. U.S. Department of Commerce. October. 1983.

15 Export Promotion: Problems in Commerce's Programs. U.S. General Accounting Office. January 1989. p. 32.

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17 Ibid. p. 61.

18 "A Missed Export Opportunity", Trade and Industry, National Association of Manufacturers, October 10, 1988.

19 Balancing The National Interest, National Academy Press, 1987.

20 Hufbauer, Gary C. and Hammond-Tooke, A., U.S. Export Competitiveness and Source-of-Income Rules, Report for Export Source Coalition, January 1988.

21 Foreign Policy Report to Congress: January 21, 1985 - January 20, 1986, U.S. Department of Commerce, p. 38.

22 Commerce Department Press Release, June 2, 1989 regarding Bureau of the Census Report on manufactured exports.

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FACT SHEET

## Pilot Program for Standards Development Assistance

June 19, 1989

### Background

P.L. 100-519, section 112 directed the Department of Commerce to establish a pilot program to assist countries in the development of domestic product standards. Such assistance ensures that countries do not develop standards that serve as barriers to U.S. goods and services.

Product standards cover such things as color coding of electric wiring, cord lengths on appliances, voltage levels, and the type of measurement system (such as metric or Imperial) used for goods.

Saudi Arabia provides an immediate opportunity to lend assistance in developing standards. The Saudi government repeatedly has requested U.S. participation in an ongoing project by the Saudi Arabia Standards Organization (SASO) to develop a comprehensive standards code that will affect over 42,000 products. The five other countries comprising the Gulf Cooperation Council (GCC) -- Bahrain, Kuwait, Oman, Qatar, and the United Arab Emirates -- intend to adopt the Saudi code. These six countries together accounted for $5.7 billion in U.S. exports in 1988.

### What's at Stake for U.S. Exports

Product standards are an export promotion and jobs issue. Currently, about 165,000 U.S. jobs rely on exports to the GCC countries. Further, the American Embassy in Riyadh estimates that if U.S.-Saudi standards were compatible, U.S. exports to the region would increase by $500 million.

Clearly, the GCC countries are also an important market for our European and Japanese competitors, whose governments have sent experts to Saudi Arabia to provide technical assistance. Already, information supplied by our competitors resulted in SASO adopting product standards incompatible with ours.

U.S. HOUSE OF REPRESENTATIVES
530 House Annex No. 2, Washington, D.C. 20515 • (202) 226-3920

In February 1988, Saudi customs authorities began to enforce many of the new standards developed by SASO. Since then, American firms have experienced numerous customs problems or prohibitions on imports of products that do not have certificates of conformity with SASO codes. Examples include,

- some shipments of U.S. refrigerators were not allowed into Saudi Arabia because of improper length of the power cord.
- a container of varied goods was delayed in port for several months because the wires on the heating element of a labeling machine did not have the proper certificate.
- a U.S. exporter of fava beans active in Saudi Arabia for 20 years lost his market because he packs his beans in oil, not water.

Many other American goods will be excluded from the Saudi market unless SASO standards can be modified to accept other recognized U.S. standards. For example, a newly proposed standard for factory-built assemblies of low voltage control and switch gears is based on standards produced by the International Electrotechnical Commission (IEC). If published as drafted, the proposed standard will preclude U.S.-made control panels and switch gears that meet American National Standards Institute (ANSI) standards from being imported into Saudi Arabia.

## Funding the Pilot Program

P.L. 100-519 directed the Department of Commerce to set up a pilot program and within six months receive reimbursements from the private sector. It was not the intention to make this program permanently funded by the private sector. Rather, seeking private funds was a way to get the program started, in view of the critical timing of the SASO project. Further, the Department of Commerce was not willing to coordinate the program without the necessary funds.

During the past six months, the private sector has raised $171,000, short of the estimated $250,000 needed to establish the program and to send a standards specialist to Saudi Arabia for one year. On May 24, 1989, Rep. Mervyn Dymally introduced H.R. 2468 to authorize a scaled-down funding of $200,000 in each fiscal year 1990, 1991, and 1992. The private sector will still be called upon to provide information or experts when needed on an industry basis. Efforts are now underway to attach this bill as an amendment to the current NIST reauthorization, which will authorize NIST programs through 1992.

Providing standards development assistance is a legitimate role of the federal government. U.S. competitor nations support their domestic standard codes with aggressive government-funded programs. With an increased mandate under the 1988 Trade Act to promote U.S. exports, the Department of Commerce should be fully funded to establish and run this pilot program. A direct U.S. presence in the SASO project is necessary if we are to protect these important export markets.

## Industry Supporters

The following organizations support efforts to seek federal funding to establish and staff the product standards pilot program in Saudi Arabia.

American Businessmen of the Gulf Arab States
Contact: David Bosch
Fax: 009-6638-761-018

National Association of Manufacturers
Contact: Patty Morgan
Phone: 637-3143

National U.S.-Arab Chamber of Commerce
Contact: Mark Woodbridge
Phone: 331-8010

U.S. Chamber of Commerce
Contact: Philip Hinson
Phone: 463-5487

Westinghouse
Contact: Bill Spodak
Phone: 835-2327

If you have any questions about the pilot program, please call Teresa Taylor at the Northeast-Midwest Institute, 544-5200.

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-236260

June 22, 1989

The Honorable Robert A. Roe
Chairman, Committee on Science,
Space and Technology
House of Representatives

The Honorable Robert S. Walker
Ranking Minority Member, Committee on
Science, Space and Technology
House of Representatives

On October 20, 1988, you requested that we analyze the potential impact of proposed fee increases on sales of calibration services and standard reference materials provided by the National Institute of Standards and Technology (NIST)—formerly the National Bureau of Standards—in the Department of Commerce. As agreed with your office, to assess the impact of the fee increases, we analyzed the changes in prices and corresponding changes in service levels (demand) for calibration services and standard reference materials between fiscal years 1979 and 1988. We also evaluated the justification for proposed fiscal year 1989 fee increases that NIST submitted to your Committee on September 19, 1988.

## Results in Brief

Because data were not readily available to measure the impact of various factors that affect demand, we could not determine how much impact, if any, price changes alone had on the demand for NIST calibration services and standard reference materials between fiscal years 1979 and 1988. Our analysis suggested, however, that demand was affected by factors other than price changes, such as the market conditions for NIST customers' products and services.

In justifying its proposed fiscal year 1989 fee increases, NIST did not fully explain the nature or the likely impact of the fee increases on the demand for measurement services, which we believe would have helped the Committee evaluate the appropriateness of the increases.

## Background

Calibration services and standard reference materials assist businesses and research laboratories in precisely measuring the physical and chemical properties of materials. Calibration services generally include checking, adjusting, or characterizing particular instruments, devices, or sets of standards on a one-time-per-request basis. The cost for these services

in fiscal year 1988 averaged $471 per calibration and ranged from less than $100 to calibrate a laboratory thermometer to over $50,000 for special tests of large microwave antenna systems. Standard reference materials are certified for certain chemical properties, such as the composition of steel, or physical properties, such as the thickness or weight of coatings. They can be used for calibrating an instrument, assessing a measurement method, or assigning values to materials. In fiscal year 1988 the cost for standard reference materials averaged $144 per unit and, according to a NIST official, ranged from $39 for five microcopy test charts to $3,536 for an optical microscope linewidth-measurement standard used in manufacturing integrated circuits.

## Fees for Calibration Services

NIST's customers are charged for calibration services based on the number of tests performed on an item. In December 1987 NIST increased the price of calibration services, which had been based on its technical division's costs to perform these services and an operations surcharge of about 13 percent to cover administrative office expenses, by adding a "development surcharge" to support the development of new and improved calibration services. NIST set the development surcharge at 8 percent of the technical division's costs to perform calibration services for fiscal year 1988 and plans to increase it by 8 percent each year until the surcharge is about 40 percent of the technical division's costs in fiscal year 1992.

## Fees for Standard Reference Materials

The price of a standard reference material is based on (1) the direct cost of producing and certifying it; (2) an operations surcharge to cover packaging, inventory, sales, and distribution costs; (3) fees to cover such costs as obsolescence and differences between direct production costs and fair market value; and (4) a development surcharge that was introduced in fiscal year 1983 for the development of new and improved standard reference materials. In December 1987 NIST increased the development surcharge from 15 percent to 20 percent of the direct cost of producing a standard reference material, which on average represented only about 39 percent of NIST's total price. (The surcharge was $7.80 on average for standard reference materials costing $100.) NIST plans to increase the development surcharge by 5 percent annually until it is about 40 percent of the direct production cost in fiscal year 1992.

## Requirement That NIST Justify Further Fee Increases

Section 5114 of the Omnibus Trade and Competitiveness Act of 1988 (P.L. 100-418) requires that NIST justify in writing to the Senate Committee on Commerce, Science and Transportation and the House Committee on Science, Space and Technology all policy changes regarding fees for standard reference materials and calibration services, including a description of the anticipated impact of any proposed changes in demand for and revenues from these services.

## Changes in Factors Other Than Price Can Affect Demand for NIST Measurement Services

In analyzing the changes in real average prices and service levels for standard reference materials and calibration services between fiscal years 1979 and 1988, we found that factors other than price also affected the demand for these services.[1] According to NIST officials, price increases generally have affected the demand for NIST measurement services less than other factors, such as general economic conditions, market conditions for products or services that NIST's customers provide, and the availability and price of alternative services. The NIST officials noted that measurement service costs are negligible in comparison with the costs of equipping and operating a laboratory that uses the services. They said customer feedback has indicated that most customers (1) are willing to pay higher fees for new and improved services and (2) can adjust their budgets to the higher prices if they are aware of the price increases ahead of time. The NIST officials also observed that customers may be able to pass on price increases to their own customers or alternatively, depending on the degree of accuracy required, customers may reduce costs by using less expensive measurement services offered by private industry or increase the time between obtaining measurement services from NIST.

## Calibration Services

We found that the number of calibration tests performed increased in each year between fiscal years 1984 and 1988, even though the real average price per test also increased in each year except fiscal year 1984, indicating that changes in factors other than price also affected the demand for calibration services. For example, the largest price change, a 17-percent increase in fiscal year 1986, corresponded with a .2-percent increase in the number of tests performed. In fiscal year 1988, despite a real average price increase of 6 percent, the number of tests performed increased by 3 percent. (See app. I for a year-by-year analysis.)

[1] We analyzed NIST's average price for services in real dollars to account for inflation.

The Chief of NIST's Office of Physical Measurement Services said that the economic state of the defense and aerospace industries has been and is likely to continue to be the most important market force affecting the demand for calibration services. This is because defense procurement contracts that specify a high degree of measurement precision comprise a significant portion of the demand for calibration services.

## Standard Reference Materials

We found that price changes had some effect on the demand for standard reference materials between fiscal years 1979 and 1988. In particular, the largest price change, an increase of 23 percent in fiscal year 1983, corresponded with the largest change in demand, a decrease of 16 percent. However, factors other than price also affected the demand for standard reference materials. Both the real average price and the number of units sold increased in fiscal years 1985 and 1987, indicating that other factors overshadowed price changes. The magnitude of the fluctuations in demand in other years also reflected the effect of factors other than price. (See app. I for a year-by-year analysis.)

The Chief of the Office of Standard Reference Materials told us that several factors can affect the demand for particular standard reference materials. He said that it is not uncommon for NIST to be out of stock or have a backlog of orders for a given material. He cited, as an example, that the optical microscope linewidth-measurement standard has a waiting list of up to 2 years because (1) it is critical for producing integrated circuits, (2) NIST is the only producer of this material, and (3) NIST requires 2 weeks to produce each one. For the human serum standard reference material, although prices increased (28 percent in fiscal year 1987 and 9 percent in fiscal year 1988), sales increased even more (by 45 percent and 19 percent, respectively) because of increased quality consciousness in the clinical industry. Alternatively, he mentioned that sales of microscopy test charts dropped (from 2,335 units in fiscal year 1986 to 695 in fiscal year 1987) in large part because a major customer decided to produce its own.

## NIST's Analysis and Justification to the Committee for Fee Increases

In a letter dated September 19, 1988, the Director of NIST notified the Senate Committee on Commerce, Science and Transportation and the House Committee on Science, Space and Technology of NIST's intent to increase the development surcharge fees in fiscal year 1989. (See app. II.) The director concluded that the fiscal year 1988 development surcharge increases had "no deleterious impact" on measurement services income and that small business demand increased by 21 percent

for calibration services and declined by 1 percent for standard reference materials. Data were enclosed for both programs showing current and projected revenues from the proposed fee increases; the sales history for fiscal years 1978 through 1988, including the service levels, gross income, and average price per item; and a comparison of income collected in various categories of customers in fiscal years 1987 and 1988.

We believe NIST could have improved its analysis and presentation of information on the nature and possible impacts of the fee increases to assist the Committees in their deliberations by (1) clearly indicating that the development surcharges would be applied to only a portion of the total sales price, (2) analyzing annual changes in average prices and income using real dollars to account for inflation, (3) controlling for or explaining the likely effects of other factors on customer demand, and (4) more clearly showing the impact of price changes on customer demand. In addition, we noted that NIST could have improved its analysis of calibration services by comparing income with the number of calibrations, rather than the number of items calibrated, because NIST charges its customers on the basis of tests performed.

After we discussed our findings and observations with your office on January 30, 1989, you sent a letter to the acting Director of NIST on February 8, 1989, approving the proposed fiscal year 1989 fee increases but requesting that NIST meet with us to consider the results of our work and more clearly present data justifying any further increases. In a meeting with our staff on March 29, 1989, NIST officials agreed with our observations about how they could more clearly present information justifying future increases and added that our report would be helpful in preparing future justifications.

## Scope and Methodology

NIST officials provided us with information and statistics on the prices, service levels, and program income for calibration services and standard reference materials from fiscal years 1978 through 1988. We analyzed these data to determine the relationship between price changes and changes in service levels. To compare prices over time, we adjusted the average price for inflation by calculating a real average price by (1) adjusting yearly income to its 1982 equivalent by dividing it by the producer price index for intermediate materials, supplies, and components and (2) dividing the adjusted income by the number of calibration tests performed or units of standard reference materials sold, as appropriate. We also reviewed past, present, and planned pricing policies for these

B-200280

services but did not survey NBS's customers to obtain their views on the impact of these pricing policies.

We conducted our review in January and February 1969. We discussed the report's contents with responsible agency officials and incorporated their views where appropriate. However, as requested by your office, we did not obtain formal agency comments on a draft of this report.

As agreed with your office, we are sending copies of this report to the Secretary of Commerce and other interested parties. Copies also will be made available to others upon request. Major contributors to this report are listed in appendix III.

John M. Ols, Jr.

John M. Ols, Jr.
Director, Housing and Community
Development Issues

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Major Contributors to This Report
Resources, Community, and Economic Development Division Washington, D.C.

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**Abbreviations**

| | |
|---|---|
| GAO | General Accounting Office |
| NIST | National Institute of Standards and Technology |

Appendix I

# NIST Measurement Services: Service Levels and Income for Fiscal Years 1978-1988

Table I.1: Service Levels and Income for Calibration Services

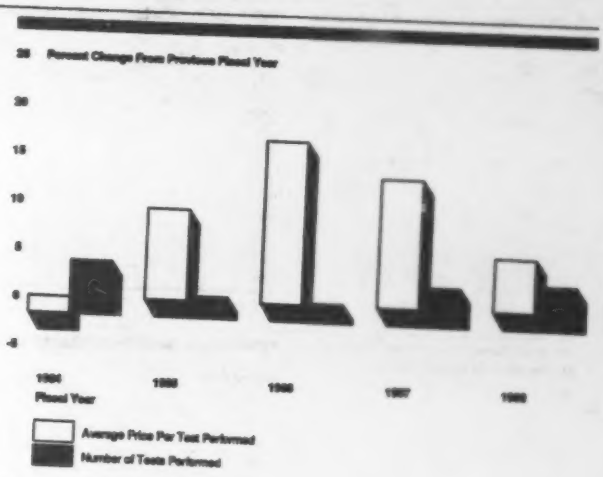
| Fiscal year | Tests performed[a] | Items calibrated | Total income (millions) |
|---|---|---|---|
| 1978 | N/A | 6,191 | $1.8 |
| 1979 | N/A | 6,924 | 2.1 |
| 1980 | N/A | 6,987 | 2.3 |
| 1981 | N/A | 7,506 | 2.5 |
| 1982 | N/A | 6,828 | 3.1 |
| 1983 | 12,209 | 8,087 | 3.6 |
| 1984 | 12,672 | 6,880 | 3.8 |
| 1985 | 12,737 | 5,779 | 4.1 |
| 1986 | 12,767 | 5,023 | 4.7 |
| 1987 | 13,059 | 5,611 | 5.5 |
| 1988 | 13,425 | 5,902 | 6.3 |

[a]NIST did not maintain records on the number of tests performed prior to fiscal year 1983.

Table I.2: Service Levels and Income for Standard Reference Materials

| Fiscal year | Units sold | Total income (millions) |
|---|---|---|
| 1978 | 37,367 | $2.5 |
| 1979 | 38,139 | 2.6 |
| 1980 | 40,847 | 3.0 |
| 1981 | 40,304 | 3.5 |
| 1982 | 39,523 | 3.8 |
| 1983 | 33,199 | 4.0 |
| 1984 | 36,674 | 4.4 |
| 1985 | 40,518 | 5.2 |
| 1986 | 40,149 | 5.2 |
| 1987 | 40,848 | 5.6 |
| 1988 | 44,484 | 6.4 |

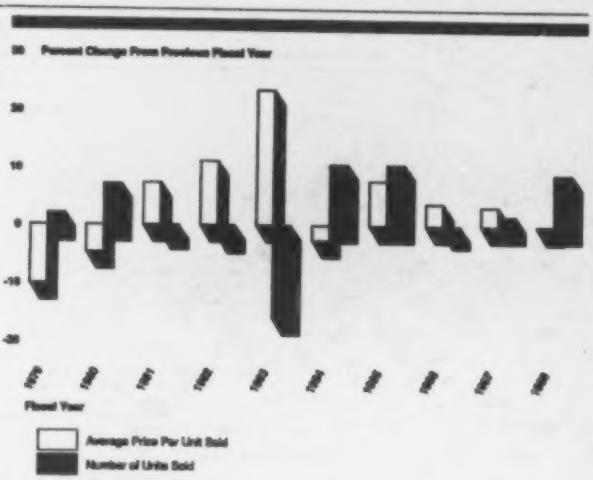
Figure I.1: Changes in Real Average Price Per Test and Number of Tests Performed for Calibration Services




Average price per unit was adjusted for inflation.

Source: Prepared by GAO from NIST data.

Figure I.2: Changes in Real Average Price Per Unit and Number of Units Sold for Standard Reference Materials




Average price per unit sold was adjusted for inflation.

Source: Prepared by GAO from NIST data.

Appendix II

# NIST's Justification for Its Fiscal Year 1989 Development Surcharge Fee Increases

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards

SEP 1 9 1988

Honorable Robert Roe
Chairman, Committee on Science,
Space and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

As I notified you last year, NIST increased its fees charged for standard reference materials and calibration services, effective December 6, 1987. This was part of our five-year plan to increase fees incrementally to a final surcharge level of approximately 40% for each service. The funds collected from the surcharges are used to offset costs associated with developing new and/or improved standard reference materials and calibrations needed by industry at large.

Improved measurement methods and standards are needed for measurement quality assurance in traditional science and technology areas, and at the same time, industry and the science communities need new measurement methods and standards for new emerging technologies. The increases for this past year have allowed NIST to further serve industry as a whole without adversely affecting individual customers, including small business. The next incremental increase in fees would allow NIST to further expand its efforts to improve its existing measurement services and develop new services.

In response to your Committee instructions dated November 17, 1987, NIST has monitored the effect of the 1988 fee increases on the demand for services and the impact on small business, non-profit organizations and other organizations with limited financial means. The data we have collected to date indicates no deleterious impact on income as a result of these fee increases and has resulted in a drop of only 1% in the income level from small business for reference materials and an increase of 21% in the level of calibration services provided to this same class of customers. I am enclosing several graphs displaying the sales history and income levels for both standard reference materials and calibrations.

Based on this review we intend to implement the second incremental increase to the fees at the beginning of fiscal year 1989. I am enclosing a chart showing current and projected revenues and surcharge rates from the increases.

UNITED STATES DEPARTMENT OF COMMERCE
National Bureau of Standards

In accordance with Section 3114 of Public Law 100-418, the Omnibus Trade and Competitiveness Act of 1988, this letter is intended to notify you of our plans to implement this user incremental fee increase.

Sincerely,
Original Signed By
Ernest Ambler

Ernest Ambler
Director

Enclosures

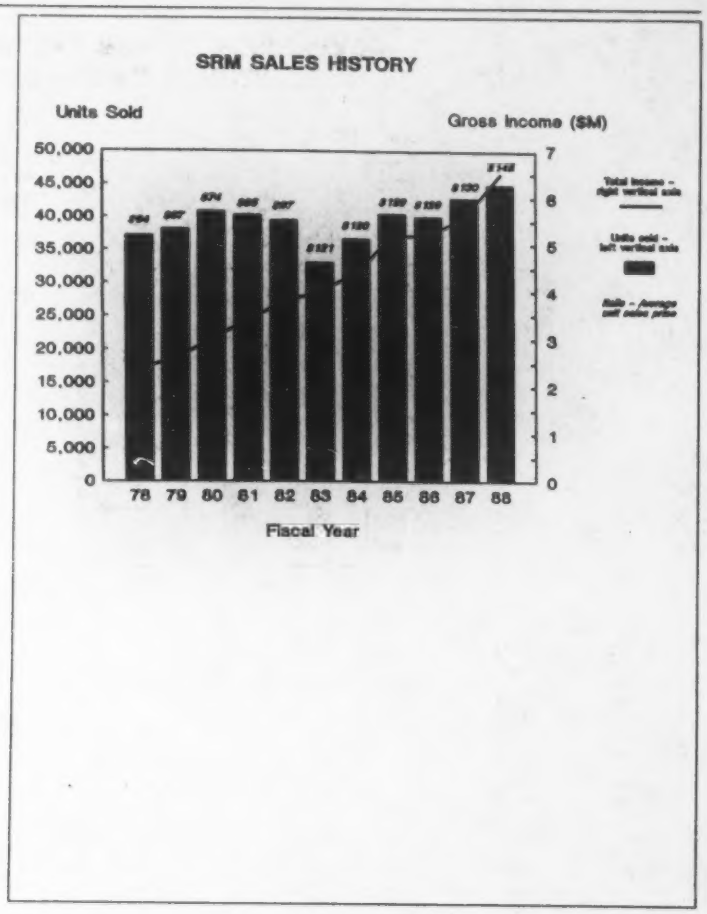
cc: Manuel Lujan, Jr.
Ranking Minority Member

Appendix H
NSTA's Justification for Its Fiscal Year 1989
Development Surcharge Fee Increases

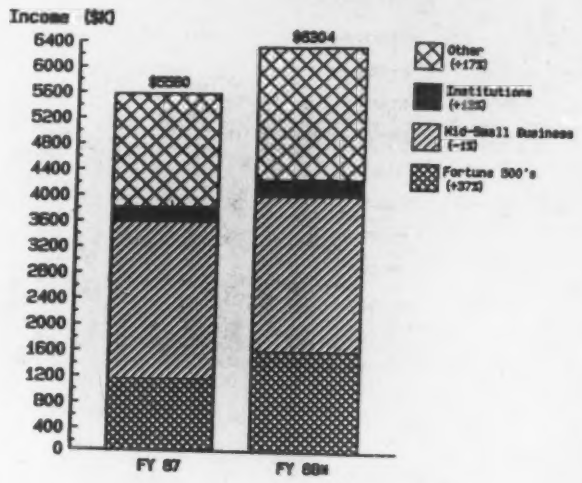
Current and Projected Revenues from Proposed Fee Increases

| | FY 87 | FY 88 | FY 89 | FY 90 | FY 91 | FY 92 |
|---|---|---|---|---|---|---|
| Calibrations | | | | | | |
| Technical service level: | ... | $3.5M | $6M | $6M | $6M | $6M |
| Development surcharge rate applied: | ... | 8% | 16% | 24% | 32% | 40% |
| Development funds from customer fees annually ($K): | ... | 250 a/ | 960 | 1,440 | 1,920 | 2,400 |
| Change margin: | ... | +250 | +710 | +480 | +480 | +480 |
| RMS | | | | | | |
| Production costs: | $2.3M | $2.3M | $2.4M | $2.4M | $2.4M | $2.4M |
| Development surcharge rate applied: | 15% | 20% | 25% | 30% | 35% | 40% |
| Development funds from customer fees annually ($K): | 348 | 463 | 600 | 720 | 840 | 960 |
| Change margin: | ---- | +115 | +137 | +120 | +120 | +120 |
| Total combined cumulative | 348 | 713 | 1,360 | 2,160 | 2,760 | 3,360 |

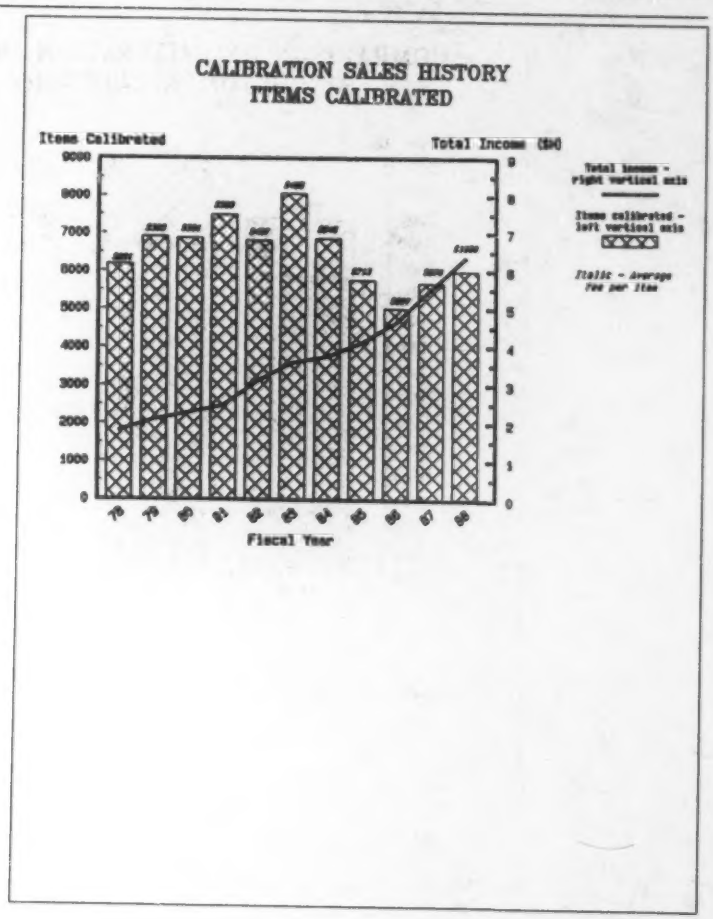
a/ Lapsed resulting from delayed implementation for fiscal year 1988.

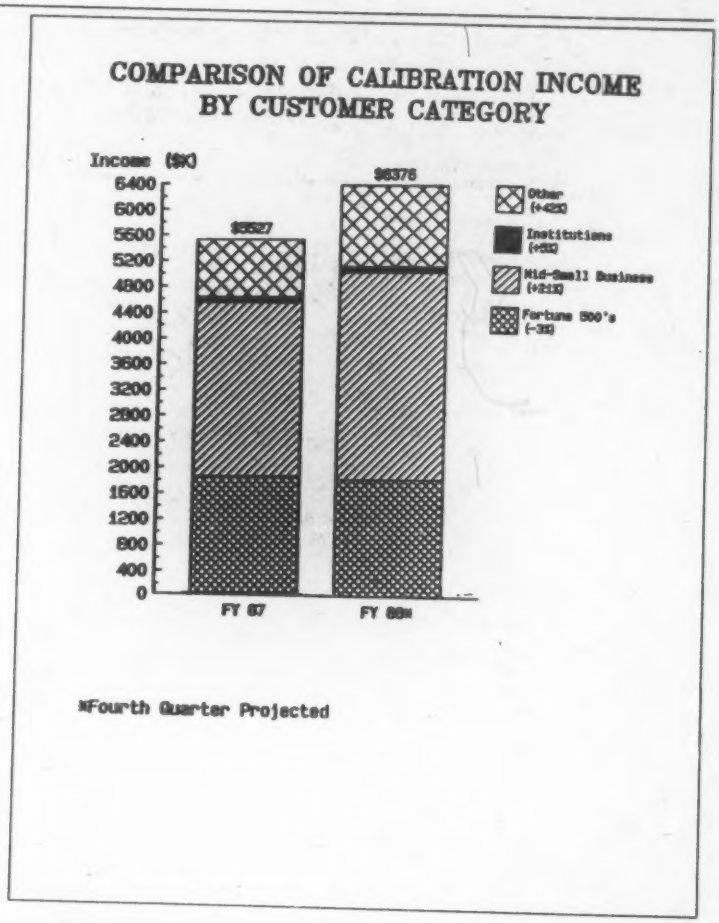

SRM SALES HISTORY
Units Sold
Gross Income ($M)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
7
6
5
4
3
2
1
0
78 79 80 81 82 83 84 85 86 87 88
Fiscal Year

## COMPARISON OF SRM INCOME BY CUSTOMER CATEGORY




*Fourth Quarter Projected


CALIBRATION SALES HISTORY
ITEMS CALIBRATED
Items Calibrated
Total Income ($M)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
9
8
7
6
5
4
3
2
1
0
Total income - right vertical axis
Items calibrated - left vertical axis
Italic - Average fee per item
Fiscal Year


COMPARISON OF CALIBRATION INCOME
BY CUSTOMER CATEGORY
Income ($K)
6400
6000
5600
5200
4800
4400
4000
3600
3200
2800
2400
2000
1600
1200
800
400
0
$5527
$6376
FY 87
FY 88*
Other
(+42%)
Institutions
(+0%)
Mid-Small Business
(+21%)
Fortune 500's
(-3%)
*Fourth Quarter Projected

Appendix III

# Major Contributors to This Report

| | |
|---|---|
| Resources, Community, and Economic Development Division Washington, D.C. | John M. Ols, Jr., Director, Housing and Community Development Issues, (202) 275-5525<br>Lowell Mininger, Assistant Director<br>Richard Cheston, Assignment Manager<br>Linda J. Weber, Evaluator-in-Charge<br>Mehrzad Nadji, Economist |

MAY 04 1989

UNITED STATES DEPARTMENT OF COMMERCE
The Under Secretary for Technology
Washington, D.C. 20230

April 24, 1989

Honorable George E. Brown, Jr.
Committee on Science, Space and Technology
U.S. House of Representatives
Washington, D. C. 20515-6301

Dear Mr. Brown:

I am pleased to submit responses to questions presented to the Technology Administration during the FY 1990 Authorization Hearings pertaining to the Metric Program.

I will be happy to provide any additional information that you may require.

Sincerely,

Lee W. Mercer
Deputy Under Secretary for
Technology

Enclosure

"Questions Submitted by Mr. Brown"

Metric Issues

QUESTION:

What plans do you have for implementing the Metric Conversion Act as mandated in Section 5164 of the Trade Act?

ANSWER:

Beyond planning the Department of Commerce metrication activity as described in a forthcoming Department Administrative Order, we are helping other agencies plan their use of metric in procurement, grants and other business-related activities. This is done through the Interagency Committee on Metric Policy (ICMP) and its working arm, the Metrication Operation Committee (MOC), which are chaired by the Technology Administration.

To provide assistance and coordination to the other agencies, we plan to publish a new Metric Handbook for Federal officials to promote consistency in metrication plans and actions of over 40 ICMP agencies.

Through the ICMP/MOC structure we have a special subcommittee chaired by the Small Business Administration to assure compliance with special considerations for small business in the Act.

By letter from the Secretary to all U. S. Governors and through their appointed members of the National Council of State Metrication (NCSM), we are assuring that the states are alerted to provisions of the Trade Act and informed of Federal planning.

We continue to work closely with the American National Metric Council (ANMC), and the U. S. Metric Association (USMA) for coordination with private sector metrication activity. We are co-sponsoring with them, a "National Metric Conference" to be held in Washington, D. C. in October 1989. A major purpose of the conference is to review metrication implications of the Trade Act.

QUESTION:

Why wasn't metric mentioned in the Executive Order implementing the Act and what conclusions, if any, should be drawn from this omission?

ANSWER:

OMB determined that inclusion of the metric issue in the Executive Order was not needed. No significant conclusions need be drawn from that decision.

QUESTION:

When can we expect a department order on metric to be issued?

ANSWER:

We prepared a revision to our current metric order after the passage of the Trade Act, but the activity was tabled because of the impending organization of the Technology Administration. That organization is set up and we are preparing the Order.

QUESTION:

Have any milestones been established for the Act's implementation?

ANSWER:

Several milestones have been established for the Metric Program:

June 1989 - Update the Federal Metric Policy Update, CFR 19(B);

August 1989 - Publish the Annual Metric Report of the Department of Commerce;

October 1989 - Co-sponsor with the American National Metric Council and the U.S. Metric Association the "National Metric Conference" to be held in Washington, D. C.

December 1989 - Prepare and publish the Federal Metric Status Report of the Federal Government; and

December 1989 - Prepare and publish the Metric Handbook including Guidelines for Federal Agencies.

QUESTION:

What is the current staffing level of the Office of Metric Programs and what increases are anticipated?

ANSWER:

Since transfer of metric responsibility from the U. S. Metric Board, we have maintained slightly over three staff years of effort. No increases are anticipated.

QUESTION:

Has the Metric Usage Act had any noticeable effects on metric conversion efforts? (ie: Trade Act.

ANSWER:

Some Federal Agencies (e.g. Department of Defense (DoD), General Services Administration (GSA), National Aeronautics and Space Administration (NASA) and Department of Agriculture (USDA)) have shown renewed and stronger levels of activity since passage of the Act. On a national basis interest has risen as shown by recent press coverage (e.g. The Wall Street Journal) and increased interest and activity among the technical associations (e.g. the Aerospace Industries Association).

QUESTION:

What has been the response of the various agencies for establishing guidelines to carry out the policies set forth in the Act regarding metric?

ANSWER:

So far the DoD, GSA and NASA have been the most active. DoD has issued a Departmental Policy and Metric Transition Plan and established 16 task groups to oversee DoD efforts. GSA has developed an agency directive on metric implementation and set up an agency metric committee to oversee its activities. NASA has begun to deal with metrication of its major future projects such as the space station, and is seeking to identify commercial capabilities for space-worthy parts and materials.

Semiconductor Equipment
and Materials International

S E M I

June 23, 1989

The Honorable Doug Walgren
U.S. House of Representatives
2241 Rayburn House Office Bldg.
Washington, D.C. 20515-3818

Dear Congressman Walgren:

On behalf of the members of Semiconductor Equipment and Materials International (SEMI) I want to express our support of the National Institute of Standards and Technology. SEMI member companies have benefited from the measurement research at NIST. NIST's job, assigned by Congress, is to support industry by helping to solve measurement problems. Our industry as a whole profits considerably from NIST's rather modest semiconductor program. However, there are many technical problems that NIST has not been able to tackle because their funding for this work is limited.

Our industry is composed of many small manufacturers. Few companies can afford to allocate sufficient funds to basic research needs such as measurements. Yet everyone has measurement-related problems, which are growing more difficult each year. According to device manufacturers, a quarter of their costs are for measurement-related problems.

NIST's budget for semiconductor work is only $6.5 million a year, an amount which has not kept pace with inflation and the growing technological emphasis on this area in our industry. As the industry grows more complex, NIST's work grows more vital. Accordingly, NIST has requested that Congress increase its semiconductor budget by $7.5 million for FY1991, the next budget window. This funding increase would expand NIST's activities in the in the semiconductor area.

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Money sent to NIST by Congress is earmarked for specific programs. Therefore, in order for the NIST to increase its funding for specific semiconductor-related programs, funding must be allocated by Congress to this area. In each of the past two years, NIST has proposed an expanded program to address more of the semiconductor industry's measurement problems. Each time the proposal has been unsuccessful. This year, with the support of the Congress, NIST has a better chance of succeeding.

As Chairman of the House Subcommittee on Science, Research and Technology SEMI urges your support of the NIST budget increase for FY1991 in order to allow its continued excellent work in measurement problem-solving. If the U.S. semiconductor equipment and materials industry is to succeed, government and industry must work together and use all of the resources available. NIST is a valuable asset and deserves the support of your subcommittee.

Sincerely,

William H. Reed

William H. Reed
President

cc: Jim Turner

WHR/vh